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FRIDAY, SEPTEMBER 25, 1896.

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*BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.**

ADDRESS BY THE PRESIDENT.

MY Lord Mayor, my Lords, Ladies and Gentlemen, I have first to express my deep sense of gratitude for the great honor conferred upon me by my election to the high office which I occupy to-day. It came upon me as a great surprise. The engrossing claims of surgery have prevented me for many years from attending the meetings of the Association, which excludes from her sections medicine in all its branches. This severance of the art of healing from the work of the Association was right and indeed inevitable. Not that medicine has little in common with science. The surgeon never performs an operation without the aid of anatomy and physiology; and in what is often the most difficult part of his duty, the selection of the right course to follow, he, like the physician, is guided by pathology, the science of the nature of disease, which, though very difficult from the complexity of its subject-matter, has made during the last half-century astonishing progress; so that the practice of medicine in every department is becoming more and more based on science as distinguished from empiricism. I propose on the present occasion to bring before you some illustrations of the

* Liverpool meeting, beginning September 16, 1896.

interdependence of science and the healing art; and the first that I will take is perhaps the most astonishing of all results of purely physical inquiry—the discovery of the Röntgen rays, so called after the man who first clearly revealed them to the world. Mysterious as they still are, there is one of their properties which we can all appreciate—their power of passing through substances opaque to ordinary light. There seems to be no relation whatever between transparency in the common sense of the term and penetrability to these emanations. The glasses of a pair of spectacles may arrest them while their wooden and leathern case allows them to pass almost unchecked. Yet they produce, whether directly or indirectly, the same effects as light upon a photographic plate. As a general rule, the denser any object is, the greater obstacle does it oppose to the rays. Hence, as bone is denser than flesh, if the hand or other part of the body is placed above the sensitive film enclosed in a case of wood or other light material at a suitable distance from the source of the rays, while they pass with the utmost facility through the uncovered parts of the lid of the box and powerfully affect the plate beneath, they are arrested to a large extent by the bones, so that the plate is little acted upon in the parts opposite to them, while the portions corresponding to the muscles and other soft parts are influenced in an intermediate degree. Thus a picture is obtained in which the bones stand out in sharp relief among the flesh, and anything abnormal in their shape or position is clearly displayed.

I need hardly point out what important aid this must give to the surgeon. As an instance, I may mention a case which occurred in the practice of Mr. Howard Marsh. He was called to see a severe injury of the elbow, in which the swelling was so great as to make it impossible for him by ordinary means of examination to decide whether he had to deal with a fracture or a dislocation. If it were the latter, a cure would be effected by the exercise of violence, which would be not only useless, but most injurious, if a bone was broken. By the aid of the Röntgen rays a photograph was taken in which the bone of the upper arm was clearly seen displaced forwards on those of the forearm. The diagnosis being thus established, Mr. Marsh proceeded to reduce the dislocation; and his success was proved by another photograph which showed the bones in their natural relative position.

The common metals, such as lead, iron and copper, being still denser than the osseous structures, these rays can show a bullet embedded in a bone or a needle lodged about a joint. At the last conversazione of the Royal Society a picture produced by the new photography displayed with perfect distinctness through the bony framework of the chest a halfpenny low down in a boy's gullet. It had been there for six months, causing uneasiness at the pit of the stomach during swallowing; but whether the coin really remained impacted, or, if so, what was its position, was entirely uncertain till the Röntgen rays revealed it. Dr. Macintyre, of Glasgow, who was the photographer, informs me that when the presence of the halfpenny had been thus demonstrated, the surgeon in charge of the case made an attempt to extract it, and although this was not successful in its immediate object it had the effect of dislodging the coin; for a subsequent photograph by Dr. Macintyre not only showed that it had disappeared from the gullet, but also, thanks to the wonderful penetrating power which the rays had acquired in his hands, proved that it had not lodged further down in the alimentary passage. The boy has since completely recovered.

The Röntgen rays cause certain chemical

compounds to fluoresce, and emit a faint light plainly visible in the dark; and if they are made to fall upon a translucent screen impregnated with such a salt, it becomes beautifully illuminated. If a part of the human body is interposed between the screen and the source of the rays, the bones and other structures are thrown in shadow upon it, and thus a diagnosis can be made without the delay involved in taking a photograph. It was in fact in this way that Dr. Macintyre first detected the coin in the boy's gullet. Mr. Herbert Jackson, of King's College, London, early distinguished himself in this branch of the subject. There is no reason to suppose that the limits of the capabilities of the rays in this way have yet been reached. By virtue of the greater density of the heart than the adjacent lungs, with their contained air, the form and dimensions of that organ in the living body may be displayed on the fluorescent screen, and even its movements have been lately seen by several different observers.

Such important applications of the new rays to medical practice have strongly attracted the interest of the public to them, and I venture to think that they have even served to stimulate the investigations of physicists. The eminent Professor of Physics in the University College of this city (Prof. Lodge) was one of the first to make such practical applications, and I was able to show to the Royal Society at a very early period a photograph, which he had the kindness to send me, of a bullet embedded in the hand. His interest in the medical aspect of the subject remains unabated, and at the same time he has been one of the most distinguished investigators of its purely physical side.

There is another way in which the Röntgen rays connect themselves with physiology, and may possibly influence medicine. It is found that if the skin is long exposed to their action it becomes very much irritated, affected with a sort of aggravated sunburning. This suggests the idea that the transmission of the rays through the human body may be not altogether a matter of indifference to internal organs, but may, by long-continued action, produce, according to the condition of the part concerned, injurious irritation of salutary stimulation.

This is the jubilee of Anæsthesia in surgery. That priceless blessing to mankind came from America. It had, indeed, been foreshadowed in the first year of this century by Humphry Davy, who, having found a toothache from which he was suffering relieved as he inhaled laughing gas (nitrous oxide), threw out the suggestion that it might perhaps be used for preventing pain in surgical operations. But it was not till, on September 30, 1846, Dr. W. T. G. Morton, of Boston, after a series of experiments upon himself and the lower animals, extracted a tooth painlessly from a patient whom he had caused to inhale the vapor of sulphuric ether, that the idea was fully realized. He soon afterwards publicly exhibited his method at the Massachusetts General Hospital, and after that event the great discovery spread rapidly over the civilized world. I witnessed the first operation in England under ether. It was performed by Robert Liston in University College Hospital, and it was a complete success. Soon afterwards I saw the same great surgeon amputate the thigh as painlessly, with less complicated anæsthetic apparatus, by aid of another agent, chloroform, which was being powerfully advocated as a substitute for ether by Dr. (afterwards Sir James Y.) Simpson, who also had the great merit of showing that confinements could be conducted painlessly, yet safely, under its influence. These two agents still hold the field as general anæsthetics for protracted operations, although the gas originally suggested by Davy, in consequence of its rapid action and other advantages, has taken their

place in short operations, such as tooth extraction. In the birthplace of anæsthesia ether has always maintained its ground; but in Europe it was to a large extent displaced by chloroform till recently, when many have returned to ether, under the idea that, though less convenient, it is safer. For my own part, I believe that chloroform, if carefully administered on right principles, is, on the average, the safer agent of the two.

The discovery of anæsthesia inaugurated a new era in surgery. Not only was the pain of operations abolished, but the serious and sometimes mortal shock which they occasioned to the system was averted, while the patient was saved the terrible ordeal of preparing to endure them. At the same time the field of surgery became widely extended, since many procedures in themselves desirable, but before impossible from the protracted agony they would occasion, became matters of routine practice. Nor have I by any means exhausted the list of the benefits conferred by this discovery.

Anæsthesia in surgery has been from the first to last a gift of science. Nitrous oxide, sulphuric ether and chloroform are all artificial products of chemistry, their employment as anæsthetics was the result of scientific investigation, and their administration, far from being, like the giving of a dose of medicine, a matter of rule of thumb, imperatively demands the vigilant exercise of physiological and pathological knowledge.

While rendering such signal service to surgery, anæsthetics have thrown light upon biology generally. It has been found that they exert their soporific influence not only upon vertebrata, but upon animals so remote in structure from man as bees and other insects. Even the functions of vegetables are suspended by their agency. They thus afford strong confirmation of the great generalization that living matter is of the same essential nature wherever it is met with on this planet, whether in the animal or vegetable kingdom. Anæsthetics have also, in ways to which I need not here refer, powerfully promoted the progress of physiology and pathology.

My next illustration may be taken from the work of Pasteur on fermentation. The prevailing opinion regarding this class of phenomena when they first engaged his attention was that they were occasioned primarily by the oxygen of the air acting upon unstable animal or vegetable products, which, breaking up under its influence, communicated disturbance to other organic materials in their vicinity, and thus led to their decomposition. Cagniard-Latour had, indeed, shown several years before that yeast consists essentially of the cells of a microscopic fungus which grows as the sweetwort ferments; and he had attributed the breaking up of the sugar into alcohol and carbonic acid to the growth of the micro-organism. In Germany Schwann, who independently discovered the yeast plant, had published very striking experiments in support of analogous ideas regarding the putrefaction of meat. Such views had also found other advocates, but they had become utterly discredited, largely through the great authority of Liebig, who bitterly opposed them.

Pasteur, having been appointed as a young man Dean of the Faculty of Sciences in the University of Lille, a town where the products of alcoholic fermentation were staple articles of manufacture, determined to study that process thoroughly; and, as a result, he became firmly convinced of the correctness of Cagniard-Latour's views regarding it. In the case of other fermentations, however, nothing fairly comparable to the formation of yeast had till then been observed. This was now done by Pasteur for that fermentation in which sugar is resolved into lactic acid. This lactic fermentation was at that time brought about by adding some

animal substance, such as fibrin, to a solution of sugar, together with chalk that should combine with the acid as it was formed. Pasteur saw, what had never before been noticed, that a fine gray deposit was formed, differing little in appearance from the decomposing fibrin, but steadily increasing as the fermentation proceeded. Struck by the analogy presented by the increasing deposit to the growth of yeast in sweetwort, he examined it with the microscope, and found it to consist of minute particles of uniform size. Pasteur was not a biologist, but although these particles were of extreme minuteness in comparison with the constituents of the yeast plant, he felt convinced that they were of an analogous nature, the cells of a tiny microscopic fungus. This he regarded as the essential ferment, the fibrin or other so-called ferment serving, as he believed, merely the purpose of supplying to the growing plant certain chemical ingredients not contained in the sugar, but essential to its nutrition. And the correctness of this view he confirmed in a very striking manner, by doing away with the fibrin or other animal material altogether, and substituting for it mineral salts containing the requisite chemical elements. A trace of the gray deposit being applied to a solution of sugar containing these salts, in addition to the chalk, a brisker lactic fermentation ensued than could be procured in the ordinary way.

I have referred to this research in some detail because it illustrates Pasteur's acuteness as an observer and his ingenuity in experiment, as well as his almost intuitive perception of truth.

A series of other beautiful investigations followed, clearly proving that all true fermentations, including putrefaction, are caused by the growth of micro-organisms.

It was natural that Pasteur should desire to know how the microbes which he showed to be the essential causes of the various fermentations took their origin. It was at that period a prevalent notion, even among many eminent naturalists, that such humble and minute beings originated *de novo* in decomposing organic substances; the doctrine of spontaneous generation, which had been chased successively from various positions which it once occupied among creatures visible to the naked eye, having taken its last refuge where the objects of study were of such minuteness that their habits and history were correspondingly difficult to trace. Here again Pasteur at once saw, as if by instinct, on which side the truth lay; and perceiving its immense importance, he threw himself with ardour into its demonstration. I may describe briefly one class of experiments which he performed with this object. He charged a series of narrow-necked glass flasks with a decoction of yeast, a liquid peculiarly liable to alteration on exposure to the air. Having boiled the liquid in each flask, to kill any living germs it might contain, he sealed its neck with a blowpipe during ebullition; after which the flask being allowed to cool, the stream within it condensed, leaving a vacuum above the liquid. If, then, the neck of the flask were broken in any locality, the air at that particular place would rush in to fill the vacuum, carrying with it any living microbes that might be floating in it. The neck of the flask having been again sealed, any germs so introduced would in due time manifest their presence by developing in the clear liquid. When any of such a series of flasks were opened and re-sealed in an inhabited room, or under the trees of a forest, multitudes of minute living forms made their appearance in them; but if this was done in a cellar long unused, where the suspended organisms, like other dust, might be expected to have all fallen to the ground, the decoction remained perfectly clear and unaltered. The oxygen and other gaseous

constituents of the atmosphere were thus shown to be of themselves incapable of inducing any organic development in yeast water.

Such is a sample of the many well-devised experiments by which he carried to most minds the conviction that, as he expressed it, '*la génération spontanée est une chimère*,' and that the humblest and minutest living organisms can only originate by parentage from beings like themselves.

Pasteur pointed out the enormous importance of these humble organisms in the economy of nature. It is by their agency that the dead bodies of plants and animals are resolved into simpler compounds fitted for assimilation by new living forms. Without their aid the world would be, as Pasteur expresses it, *encombré de cadavres*. They are essential not only to our well-being, but to our very existence. Similar microbes must have discharged the same necessary function of removing refuse and providing food for successive generations of plants and animals during the past periods of the world's history; and it is interesting to think that organisms as simple as can well be conceived to have existed when life first appeared upon our globe have, in all probability, propagated the same lowly but must useful offspring during the ages of geological time.

Pasteur's labors on fermentation have had a very important influence upon surgery. I have been often asked to speak on my share in this matter before a public audience; but I have hitherto refused to do so, partly because the details are so entirely technical, but chiefly because I have felt an invincible repugnance to what might seem to savor of self-advertisement. The latter objection now no longer exists, since advancing years have indicated that it is right for me to leave to younger men the practice of my dearly loved profession. And it will perhaps be expected that, if I can make myself intelligible, I should say something upon the subject on the present occasion.

Nothing was formerly more striking in surgical experience than the difference in the behavior of injuries according to whether the skin was implicated or not. Thus, if the bones of the leg were broken and the skin remained intact, the surgeon applied the necessary apparatus without any other anxiety than that of maintaining a good position of the fragments, although the internal injury to bones and soft parts might be very severe. If, on the other hand, a wound of the skin was present, communicating with the broken bones, although the damage might be in other respects comparitively slight, the compound fracture, as it was termed, was one of the most dangerous accidents that could happen. Mr. Syme, who was, I believe, the safest surgeon of his time, once told me that he was inclined to think that it would be, on the whole, better if all compound fractures of the leg were subjected to amputation, without any attempt to save the limb. What was the cause of this astonishing difference? It was clearly in some way due to the exposure of the injured parts to the external world. One obvious effect of such exposure was indicated by the odor of the discharge, which showed that the blood in the wound had undergone putrefactive change by which the bland nutrient liquid had been converted into highly irritating and poisonous substances. I have seen a man with compound fracture of the leg die within two days of the accident, as plainly poisoned by the products of putrefaction as if he had taken a fatal dose of some potent toxic drug.

An external wound of the soft parts might be healed in one of two ways. If its surfaces were clean cut, and could be brought into accurate apposition, it might unite rapidly and painlessly 'by the first intention.' This, however, was exceptional.

Too often the surgeon's efforts to obtain primary union were frustrated, the wound inflamed and the retentive stitches had to be removed, allowing it to gape; and then, as if it had been left open from the first, healing had to be effected in the other way which it is necessary for me briefly to describe. An exposed raw surface became covered in the first instance with a layer of clotted blood or certain of its constituents, which invariably putrefied; and the irritation of the sensitive tissues by the putrid products appeared to me to account sufficiently for the inflammation which always occurred in and around an open wound during the three or four days which elapsed before what were termed 'granulations' had been produced. These constituted a coarsely granular coating of very imperfect or embryonic structure, destitute of sensory nerves and prone to throw off matter or pus, rather than absorb, as freshly divided tissues do, the products of putrefaction. The granulations thus formed a beautiful living plaster, which protected the sensitive parts beneath from irritation, and the system generally from poisoning and consequent febrile disturbance. The granulations had other useful properties, of which I may mention their tendency to shrink as they grew, thus gradually reducing the dimensions of the sore. Meanwhile, another cause of its diminution was in operation. The cells of the epidermis, or scarfskin of the cutaneous margins, were perpetually producing a crop of young cells of similar nature, which gradually spread over the granulations till they covered them entirely, and a complete cicatrix or scar was the result. Such was the other mode of healing that, by granulation and cicatrisation, a process which, when it proceeded unchecked to its completion, commanded our profound admiration. It was, however, essentially tedious compared with primary union, while, as we have seen, it was always preceded by more or less inflammation and fever, sometimes very serious in their effects. It was also liable to unforseen interruptions. The sore might become larger instead of smaller, cicatrisation giving place to ulceration in one of its various forms, or even to the frightful destruction of tissue which, from the circumstance that it was most frequently met with in hospitals, was termed hospital gangrene. Other serious and often fatal complications might arise, which the surgeon could only regard as untoward accidents and over which he had no efficient control.

It will be readily understood from the above description that the inflammation which so often frustrated the surgeon's endeavors after primary union was, in my opinion, essentially due to decomposition of blood within the wound.

These and many other considerations had long impressed me with the greatness of the evil of putrefaction in surgery. I had done my best to mitigate it by scrupulous ordinary cleanliness and the use of various deodorant lotions. But to prevent it altogether appeared hopeless while we believed with Liebeg that its primary cause was the atmospheric oxygen which, in accordance with the researches of Graham, could not fail to be perpetually diffused through the porous dressings which were used to absorb the blood discharged from the wound. But when Pasteur had shown that putrefaction was a fermentation caused by the growth of microbes, and that these could not arise *de novo* in the decomposable substance, the problem assumed a more hopeful aspect. If the wound could be treated with some substance which, without doing too serious mischief to the human tissues, would kill the microbes already contained in it and prevent the future access of others in the living state, putrefaction might be prevented, however freely the air with its oxygen might enter. I had heard of carbolic

acid as having a remarkable deodorising effect upon sewage, and having obtained from my colleague, Dr. Anderson, Professor of Chemistry in the University of Glasgow, a sample which he had of this product, then little more than a chemical curiosity in Scotland, I determined to try it in compound fractures. Applying it undiluted to the wound, with an arrangement for its occasional renewal, I had the joy of seeing these formidable injuries follow the same safe and tranquil course as simple fractures, in which the skin remains unbroken.

At the same time we had the intense interest of observing in open wounds what had previously been hidden from human view—the manner in which subcutaneous injuries are repaired. Of special interest was the process by which portions of tissue killed by the violence of the accident were disposed of, as contrasted with what had till then been invariably witnessed. Dead parts had been always seen to be gradually separated from the living by an inflammatory process and thrown off as sloughs. But when protected by the antiseptic dressing from becoming putrid and therefore irritating, a structure deprived of its life caused no disturbance in its vicinity; and on the contrary, being of a nutritious nature, it served as pabulum for the growing elements of the neighboring living structures, and these became in due time entirely substituted for it. Even dead bone was seen to be thus replaced by living osseous tissue.

This suggested the idea of using threads of dead animal tissue for tying blood vessels; and this was realized by means of catgut, which is made from the intestine of the sheep. If deprived of living microbes, and otherwise properly prepared, catgut answers its purpose completely; the knot holding securely, while the ligature around the vessel becomes gradually absorbed and replaced by a ring of living tissue. The threads, instead of being left long as before, could now be cut short, and the tedious process of separation of the ligature, with its attendant serious danger of bleeding, was avoided.

Undiluted carbolic acid is a powerful caustic; and although it might be employed in compound fracture, where some loss of tissue was of little moment in comparison with the tremendous danger to be averted, it was altogether unsuitable for wounds made by the surgeon. It soon appeared, however, that the acid would answer the purpose aimed at, though used in diluted forms devoid of caustic action, and therefore applicable to operative surgery. According to our then-existing knowledge, two essential points had to be aimed at: to conduct the operation so that on its completion the wound should contain no living microbes; and to apply a dressing capable of preventing the access of other living organisms till the time should have arrived for changing it.

Carbolic acid lent itself well to both these objects. Our experience with this agent brought out what was, I believe, a new principle in pharmacology—namely, that the energy of action of any substance upon the human tissues depends not only upon the proportion in which it is contained in the material used as a vehicle for its administration, but also upon the degree of tenacity with which it is held by its solvent. Water dissolves carbolic acid sparingly and holds it extremely lightly, leaving it free to act energetically on other things for which it has greater affinity, while various organic substances absorb it greedily and hold it tenaciously. Hence its watery solution seemed admirably suited for a detergent lotion to be used during the operation for destroying any microbes that might fall upon the wound, and for purifying the surrounding skin and also the surgeon's hands and instruments. For the last-named purpose it had the further advantage that it did not act on steel.

For an external dressing the watery solution was not adapted, as it soon lost the acid it contained, and was irritating while it lasted. For this purpose some organic substances were found to answer well. Large proportions of the acid could be blended with them in so bland a form as to be unirritating; and such mixtures, while perpetually giving off enough of the volatile salt to prevent organic development in the discharges that flowed past them, served as a reliable store of the antiseptic for days together.

The appliances which I first used for carrying out the antiseptic principle were both rude and needlessly complicated. The years that have since passed have witnessed great improvements in both respects. Of the various materials which have been employed by myself and others, and their modes of application, I need say nothing except to express my belief, as a matter of long experience, that carbolic acid, by virtue of its powerful affinity for the epidermis and oily matters associated with it, and also its great penetrating power, is still the best agent at our disposal for purifying the skin around the wound. But I must say a few words regarding a most important simplification of our procedure. Pasteur, as we have seen, had shown that the air of every inhabited room teems with microbes; and for a long time I employed various more or less elaborate precautions against the living atmospheric dust, not doubting that, as all wounds except the few which healed completely by the first intention underwent putrefactive fermentation, the blood must be a peculiarly favorable soil for the growth of putrefactive microbes. But I afterwards learnt that such was by no means the case. I had performed many experiments in confirmation of Pasteur's germ theory, not indeed in order to satisfy myself of its truth, but in the hope of convincing others. I had observed that uncontaminated milk, which would remain unaltered for an indefinite time if protected from dust, was made to teem with microbes of different kinds by a very brief exposure to the atmosphere, and that the same effect was produced by the addition of a drop of ordinary water. But when I came to experiment with blood drawn with antiseptic precautions into sterilized vessels, I saw, to my surprise, that it might remain free from microbes, in spite of similar access of air or treatment with water. I even found that if very putrid blood was largely diluted with sterilized water, so as to diffuse its microbes widely and wash them of their acrid products, a drop of such dilution added to pure blood might leave it unchanged for days at the temperature of the body, although a trace of the septic liquid undiluted caused intense putrefaction within twenty-four hours. Hence I was led to conclude that it was the goosser forms of septic mischief, rather than microbes in the attenuated condition in which they existed in the atmosphere, that we had to dread in surgical practice. And at the London Medical Congress, in 1881, I hinted, when describing the experiments I have alluded to, that it might turn out possible to disregard altogether the atmospheric dust. But greatly as I should have rejoiced at such a simplification of our procedure, if justifiable, I did not then venture to test it in practice. I knew that with the safeguards which we then employed I could ensure the safety of my patients, and I did not dare to imperil it by relaxing them. There is one golden rule for all experiments upon our fellowmen. Let the thing tried be that which, according to our best judgment, is the most likely to promote the welfare of the patient. In other words, do as you would be done by.

Nine years later, however, at the Berlin Congress in 1890, I was able to bring forward what was, I believe, absolute demon-

stration of the harmlessness of the atmospheric dust in surgical operations. This conclusion has been justified by subsequent experience; the irritation of the wound by antiseptic irrigation and washing may therefore now be avoided, and nature left quite undisturbed to carry out her best methods of repair, while the surgeon may conduct his operations as simply as in former days, provided always that, deeply impressed with the tremendous importance of his object, and inspiring the same conviction in all his assistants, he vigilantly maintains from first to last, with care that, once learnt, becomes instinctive, but for the want of which nothing else can compensate, the use of the simple means which will suffice to exclude from the wound the coarser forms of septic impurity.

Even our earlier and ruder methods of carrying out the antiseptic principle soon produced a wonderful change in my surgical wards in the Glasgow Royal Infirmary, which, from being some of the most unhealthy in the kingdom, became, as I believe I may say without exaggeration, the healthiest in the world; while other wards, separated from mine only by a passage a few feet broad, where former modes of treatment were for a while continued, retained their former insalubrity. This result, I need hardly remark, was not in any degree due to special skill on my part, but simply to the strenuous endeavor to carry out strictly what seemed to me a principle of supreme importance.

Equally striking changes were afterwards witnessed in other institutions. Of these I may give one example. In the great Allgemeines Krankenhaus, of Munich, hospital gangrene had become more and more rife from year to year, till at length the frightful condition was reached that 80 per cent. of all wounds became affected by it. It is only just to the memory of Prof. von Nussbaum, then the head of that establishment, to say that he had done his utmost to check this frightful scourge; and that the evil was not caused by anything peculiar in his management was shown by the fact that in a private hospital under his care there was no unusual unhealthiness. The larger institution seemed to have become hopelessly infected, and the city authorities were contemplating its demolition and reconstruction. Under these circumstances, Prof. von Nussbaum dispatched his chief assistant, Dr. Lindpaintner, to Edinburgh, where I at that time occupied the chair of clinical surgery, to learn the details of the antiseptic system as we then practiced it. He remained until he had entirely mastered them, and after his return all the cases were on a certain day dressed on our plan. From that day forward not a single case of hospital gangrene occurred in the Krankenhaus. The fearful disease pyæma likewise disappeared, and erysipelas soon followed its example.

But it was by no means only in removing the unhealthiness of hospitals that the antiseptic system showed its benefits. Inflammation being suppressed, with attendant pain, fever and wasting discharge, the sufferings of the patient were, of course, immensely lessened; rapid primary union being now the rule, convalescence was correspondingly curtailed; while, as regards safety and the essential nature of the mode of repair, it became a matter of indifference whether the wound had clean-cut surfaces which could be closely approximated, or whether the injury inflicted had been such as to cause destruction of tissue. And operations which had been regarded from time immemorial as unjustifiable were adopted with complete safety.

It pleases me to think that there is an ever-increasing number of practitioners throughout the world to whom this will not appear the language of exaggeration. There are cases in which, from the situation of

the part concerned or other unusual circumstances, it is impossible to carry out the antiseptic system completely. These, however, are quite exceptional; and even in them much has been done to mitigate the evil which cannot be altogether avoided.

I ask your indulgence if I have seemed to dwell too long upon matters in which I have been personally concerned. I now gladly return to the labors of others.

The striking results of the application of the germ theory to surgery acted as a powerful stimulus to the investigation of the nature of the micro-organisms concerned; and it soon appeared that putrefaction was by no means the only evil of microbic origin to which wounds were liable. I had myself very early noticed that hospital gangrene was not necessarily attended by any unpleasant odor; and I afterwards made a similar observation regarding the matter formed in a remarkable epidemic of erysipelas in Edinburgh obviously of infective character. I had also seen a careless dressing followed by the occurrence of suppuration without putrefaction. And as these non-putrefactive disorders had the same self-propagating property as ferments, and were suppressed by the same antiseptic agencies which were used for combating the putrefactive microbes, I did not doubt that they were of an analogous origin; and I ventured to express the view that, just as the various fermentations had each its special microbe, so it might be with the various complications of wounds. This surmise was afterwards amply verified. Prof. Ogston, of Aberdeen, was an early worker in this field, and showed that in acute abscesses, that is to say, those which run a rapid course, the matter, although often quite free from unpleasant odor, invariably contains micro-organisms belonging to the group which, from the spherical form of their elements, are termed micrococci; and these he classed as streptococci or staphylococci, according as they were arranged in chains or disposed in irregular clusters like bunches of grapes. The German pathologist, Fehleisen, followed with a beautiful research, by which he clearly proved that erysipelas is caused by a streptococcus. A host of earnest workers in different countries have cultivated the new science of Bacteriology, and, while opening up a wide fresh domain of Biology, have demonstrated in so many cases the causal relation between special micro-organisms and special diseases, not only in wounds, but in the system generally, as to afford ample confirmation of the induction which had been made by Pasteur that all infective disorders are of microbic origin.

Not that we can look forward with anything like confidence to being able to see the *materies morbi* of every disease of this nature. One of the latest of such discoveries has been that by Pfeiffer, of Berlin, of the bacillus of influenza, perhaps the most minute of all micro-organisms ever yet detected. The bacillus of anthrax, the cause of a plague common among cattle in some parts of Europe, and often communicated to sorters of foreign wool in this country, is a giant as compared with this tiny being; and supposing the microbe of any infectious fever to be as much smaller than the influenza bacillus as this is less than that of anthrax, a by no means unlikely hypothesis, it is probable that it would never be visible to man. The improvements of the microscope, based on the principle established by my father in the earlier part of the century, have apparently nearly reached the limits of what is possible. But that such parasites are really the causes of all this great class of diseases can no longer be doubted.

The first rational step towards the prevention or cure of disease is to know its cause; and it is impossible to over-estimate the practical value of researches, such as those to which I am now referring. Among

their many achievements is what may be fairly regarded as the most important discovery ever made in pathology, because it revealed the true nature of the disease which causes more sickness and death in the human race than any other. It was made by Robert Koch, who greatly distinguished himself, when a practitioner in an obscure town in Germany, by the remarkable combination of experimental acuteness and skill, chemical and optical knowledge and successful micro-photography which he brought to bear upon the illustration of infective diseases of wounds in the lower animals; in recognition of which service the enlightened Prussian government at once appointed him to an official position of great importance in Berlin. There he conducted various important researches; and at the London Congress, in 1881, he showed to us, for the first time, the bacillus of tubercle. Wonderful light was thrown, by this discovery, upon a great group of diseases which had before been rather guessed than known to be of an allied nature; a precision and efficacy never before possible was introduced into their surgical treatment, while the physician became guided by new and sure light as regards their diagnosis and prevention.

At that same London Congress Koch demonstrated to us his 'plate culture' of bacteria, which was so important that I must devote a few words to its description. With a view to the successful study of the habits and effects of any particular microbe outside the living body it is essential that it should be present unmixed in the medium in which it is cultivated. It can be readily understood how difficult it must have been to isolate any particular micro-organism when it existed mixed, as was often the case, with a multitude of other forms. In fact, the various ingenious attempts made to effect this object had often proved entire failures. Koch, however, by an ingenious procedure converted what had been before impossible into a matter of the utmost facility. In the broth or other nutrient liquid which was to serve as food for the growing microbe he dissolved, by aid of heat, just enough gelatine to ensure that, while it should become a solid mass when cold, it should remain fluid, though reduced in temperature so much as to be incapable of killing living germs. To the medium thus partially cooled was added some liquid containing, among others, the microbe to be investigated; and the mixture was thoroughly shaken so as to diffuse the bacteria and separate them from each other. Some of the liquid was then poured out in a thin layer upon a glass plate and allowed to cool so as to assume the solid form. The various microbes, fixed in the gelatine and so prevented from intermingling, proceeded to develop each its special progeny, which in course of time showed itself as an opaque speck in the transparent film. Any one of such specks could now be removed and transferred to another vessel in which the microbe composing it grew in perfect isolation.

Pasteur was present at this demonstration, and expressed his sense of the great progress effected by the new method. It was soon introduced into his own institute and other laboratories throughout the world; and it has immensely facilitated bacteriological study.

One fruit of it in Koch's own hands was the discovery of the microbe of cholera in India, whither he went to study the disease. This organism was termed by Koch from its curved form the 'comma bacillus,' and by the French the cholera vibrio. Great doubts were for a long time felt regarding this discovery. Several other kinds of bacteria were found of the same shape, some of them producing very similar appearances in culture media. But bacteriologists are now universally agreed that, although va-

rious other conditions are necessary to the production of an attack of cholera besides the mere presence of the vibrio, yet it is the essential *materies morbi;* and it is by the aid of the diagnosis which its presence in any case of true cholera enables the bacteriologist to make, that threatened invasions of this awful disease have of late years been so successfully repelled from our shores. If bacteriology had done nothing more for us than this it might well have earned our gratitude.

I have next to invite your attention to some earlier work of Pasteur. There is a disease known in France under the name of *choléra des poules*, which often produced great havoc among the poultry yards of Paris. It had been observed that the blood of birds that had died of this disease was peopled by a multitude of minute bacteria, not very dissimilar in form and size to the microbe of the lactic ferment to which I have before referred. And Pasteur found that, if this bacterium was cultivated outside the body for a protracted period under certain conditions, it underwent a remarkable diminution of its virulence; so that, if inoculated into a healthy fowl, it no longer caused the death of the bird, as it would have done in its original condition, but produced a milder form of the disease which was not fatal. And this altered character of the microbe, caused by certain conditions, was found to persist in successive generations cultivated in the ordinary way. Thus was discovered the great fact, of what Pasteur termed *atténuation des virus*, which at once gave the clue to understanding what had before been quite mysterious, the difference in virulence of the same disease in different epidemics.

But he made the further very important observation that a bird which had gone through the mild form of the complaint had acquired immunity against it in its most virulent condition. Pasteur afterwards succeeded in obtaining mitigated varieties of microbes for some other diseases; and he applied with great success the principle which he had discovered in fowl-cholera for protecting the larger domestic animals against the plague of anthrax. The preparations used for such preventive inoculations he termed 'vaccins' in honor of our great countryman, Edward Jenner. For Pasteur at once saw the analogy between the immunity to fowl-cholera produced by its attenuated virus and the protection afforded against small-pox by vaccination. And while pathologists still hesitated, he had no doubt of the correctness of Jenner's expression *variolæ vaccinæ*, or small-pox in the cow.

It is just a hundred years since Jenner made the crucial experiment of inoculating with small-pox a boy whom he had previously vaccinated, the result being, as he anticipated, that the boy was quite unaffected. It may be remarked that this was a perfectly legitimate experiment, involving no danger to the subject of it. Inoculation was at that time the established practice; and if vaccination should prove nugatory, the inoculation would be only what would have been otherwise called for; while it would be perfectly harmless if the hoped-for effect of vaccination had been produced.

We are a practical people, not much addicted to personal commemorations; although our nation did indeed celebrate, with fitting splendor, the jubilee of the reign of our beloved Queen; and, at the invitation of Glasgow, the scientific world has lately marked, in a manner, though different, as imposing, the jubilee of the life-work of a sovereign in science (Lord Kelvin). But while we cannot be astonished that the centenary of Jenner's immortal discovery should have failed to receive general recognition in this country, it is melancholy to think that this year should, in his native

county, have been distinguished by a terrible illustration of the results which would sooner or later inevitably follow the general neglect of his prescriptions.

I have no desire to speak severely of the Gloucester Guardians. They are not sanitary authorities, and had not the technical knowledge necessary to enable them to judge between the teachings of true science and the declamations of misguided, though well-meaning, enthusiasts. They did what they believed to be right; and when roused to a sense of the greatness of their mistake, they did their very best to repair it, so that their city is said to be now the best vaccinated in Her Majesty's dominions. But though by their praiseworthy exertions they succeeded in promptly checking the raging epidemic, they cannot recall the dead to life, or restore beauty to marred features, or sight to blinded eyes. Would that the entire country and our Legislature might take duly to heart this object lesson!

How completely the medical profession were convinced of the efficacy of vaccination in the early part of this century was strikingly illustrated by an account given by Prof. Crookshank, in his interesting history of this subject, of several eminent medical men in Edinburgh meeting to see the to them unprecedented fact of a vaccinated person having taken small-pox. It has, of course, since become well known that the milder form of the disease, as modified by passing though the cow, confers a less permanent protection than the original human disorder. This it was, of course, impossible for Jenner to foresee. It is, indeed, a question of degree, since a second attack of ordinary small-pox is occasionally known to occur, and vaccination, long after it has ceased to give perfect immunity, greatly modifies the character of the disorder and diminishes its danger. And happily, in re-vaccination after a certain number of years we have the means of making Jenner's work complete. I understand the majority of the Commissioners, who have recently issued their report upon this subject, while recognising the value of importance of re-vaccination, are so impressed with the difficulties that would attend making it compulsory by legislation that they do not recommend that course; although it is advocated by two of their number who are of peculiarly high authority on such a question. I was lately told by a Berlin professor that no serious difficulty is experienced in carrying out the compulsory law that prevails in Germany. The masters of the schools are directed to ascertain in the case of every child attaining the age of twelve whether re-vaccination has been practised. If not, and the parents refuse to have it done, they are fined one Mark. If this does not prove effectual, the fine is doubled; and if even the double penalty should not prove efficacious, a second doubling of it would follow, but, as my informant remarked, it is very seldom that it is called for. The result is that small-pox is a matter of extreme rarity in that country; while it is absolutely unknown in the huge German army, in consequence of the rule that every soldier is re-vaccinated on entering the service. Whatever view our Legislature may take on this question, one thing seems to me clear: that it will be the duty of Government to encourage by every available means the use of calf lymph, so as to exclude the possibility of the communication of any human disease to the child, and to institute such efficient inspection of vaccination institutes as shall ensure careful antiseptic arrangements, and so prevent contamination by extraneous microbes. If this were done, 'conscientious objections' would cease to have any rational basis. At the same time, the administration of the regulations on vaccination should be transferred (as advised by the Commissioners) to competent sanitary authorities.

But to return to Pasteur. In 1880 he entered upon the study of that terrible but then most obscure disease, hydrophobia, or rabies, which from its infective character he was sure must be of microbic origin, although no micro-organism could be detected in it. He early demonstrated the new pathological fact that the virus had its essential seat in the nervous system. This proved the key to his success in this subject. One result that flowed from it has been the cause of unspeakable consolation to many. The foolish practice is still too prevalent of killing the dog that has bitten any one, on the absurd notion that, if it were mad, its destruction would prevent the occurrence of hydrophobia in the person bitten. The idea of the bare possibility of the animal having been so affected causes an agony of suspense during the long weeks or months of possible incubation of the disease. Very serious nervous symptoms aping true hydrophobia have been known to result from the terror thus inspired. Pasteur showed that if a little of the brain or spinal cord of a dog that had been really mad was inoculated in an appropriate manner into a rabbit, it infallibly caused rabies in that animal in a few days. If, therefore, such an experiment was made with a negative result, the conclusion might be drawn with certainty that the dog had been healthy. It is perhaps right that I should say that the inoculation is painlessly done under an anæsthetic, and that in the rabbit rabies does not assume the violent form that it does in the dog, but produces gradual loss of power, with little, if any, suffering.

This is the more satisfactory because rabbits in which the disease has been thus artificially induced are employed in carrying out what was Pasteur's greatest triumph, the preventive treatment of hydrophobia in the human subject. We have seen that Pasteur discovered that microbes might under some circumstances undergo mitigation of their virulence. He afterwards found that under different conditions they might have it exalted, or, as he expressed it, there might be a *renforcement du virus*. Such proved to be the case with rabies in the rabbit; so that the spinal cords of animals which had died of it contained the poison in a highly intensified condition. But he also found that if such a highly virulent cord was suspended under strict antiseptic precautions in a dry atmosphere at a certain temperature, it gradually from day to day lost it potency, till in course of time it became absolutely inert. If now an emulsion of such a harmless cord was introduced under the skin of an animal, as in the subcutaneous administration of morphia, it might be followed without harm another day by a similar dose of a cord still rather poisonous; and so from day to day stronger and stronger ejections might be used, the system becoming gradually accustomed to the poison, till a degree of virulence had been reached far exceeding that of the bite of a mad dog. When this had been attained, the animal proved incapable of taking the disease in the ordinary way; and more than that, if such treatment was adopted after an animal had already received the poison, provided that too long a time had not elapsed, the outbreak of the disease was prevented. It was only after great searching of heart that Pasteur, after consultation with some trusted medical friends, ventured upon trying this practice upon man. It has since been extensively adopted in various parts of the world with increasing success as the details of the method were improved. It is not, of course, the case that every one bitten by a really rabid animal takes the disease; but the percentage of those who do so, which was formerly large, has been reduced almost to zero by this treatment, if not too long delayed.

While the intensity of rabies in the rabbit is undoubtedly due to a peculiarly virulent form of the microbe concerned, we cannot suppose that the daily diminishing potency of the cord suspended in dry warm air is an instance of attenuation of virus, using the term 'virus' as synonymous with the microbe concerned. In other words, we have no reason to believe that the special micro-organism of hydrophobia continues to develop in the dead cord and produce successively a milder and milder progeny, since rabies cannot be cultivated in the nervous system of a dead animal. We must rather conclude that there must be some chemical poison present which gradually loses its potency as time passes. And this leads me to refer to another most important branch of this large subject of bacteriology, that of the poisonous products of microbes.

It was shown several years ago by Roux and Yersin, working in the Institut Pasteur, that the crust or false membrane which forms upon the throats of patients affected with diptheria contains bacteria which can be cultivated outside the body in a nutrient liquid, with the result that it acquires poisonous qualities of astonishing intensity, comparable to that of the secretion of the poison glands of the most venomous serpents. And they also ascertained that the liquid retained this property after the microbes had been removed from it by filtration, which proved that the poison must be a chemical substance in solution, as distinguished from the living element which had produced it. These poisonous products of bacteria, or toxins, as they have been termed, explain the deadly effects of some microbes, which it would otherwise be impossible to understand. Thus, in diptheria itself the special bacillus which was shown by Löffler to be its cause does not become propagated in the blood, like the microbe of chicken cholera, but remains confined to the surface on which it first appeared; but the toxin which it secretes is absorbed from that surface into the blood, and so poisons the system. Similar observations have been made with regard to the microbes of some other diseases, as, for example, the bacillus of tetanus or lockjaw. This remains localized in the wound, but forms a special toxin of extreme potency, which becomes absorbed and diffused through the body.

Wonderful as it seems, each poisonous microbe appears to form its own peculiar toxin. Koch's tuberculin was of this nature, a product of the growth of the tubercle bacillus in culture media. Here, again, great effects were produced by extremely minute quantities of the substance, but here a new peculiarity showed itself, viz., that patients affected with tubercular disease, in any of its varied forms, exhibited inflammation in the affected part and general fever after receiving under the skin an amount of the material which had no effect whatever upon healthy persons. I witnessed, in Berlin, some instances of these effects, which were simply astounding. Patients affected with a peculiar form of obstinate ulcer of the face showed, after a single injection of the tuberculin, violent inflammatory redness and swelling of the sore and surrounding skin; and, what was equally surprising, when this disturbance subsided the disease was found to have undergone great improvement. By repetitions of such procedures, ulcers which had previously been steadily advancing, in spite of ordinary treatment, became greatly reduced in size, and in some instances apparently cured. Such results led Koch to believe that he had obtained an effectual means of dealing with tubercular disease in all its forms. Unhappily, the apparent cure proved to be only of transient duration, and the high hopes which had been inspired by Koch's great reputation were dashed. It is but fair to say that he

was strongly urged to publish before he was himself disposed to do so, and we cannot but regret that he yielded to the pressure put upon him.

But though Koch's sanguine anticipations were not realized, it would be a great mistake to suppose that his labors with tuberculin have been fruitless. Cattle are liable to tubercle, and, when affected with it, may become a very serious source of infection for human beings, more especially when the disease affects the udders of cows, and so contaminates the milk. By virtue of the close affinity that prevails between the lower animals and ourselves, in disease as well as in health, tuberculin produces fever in tubercular cows in doses which do not affect healthy beasts. Thus, by the subcutaneous use of a little of the fluid, tubercle latent in internal organs of an apparently healthy cow can be with certainty revealed, and the slaughter of the animal after this discovery protects man from infection.

It has been ascertained that glanders presents a precise analogy with tubercle as regards the effects of its toxic products. If the microbe which has been found to be the cause of this disease is cultivated in appropriate media it produces a poison which has received the name of mallein, and the subcutaneous injection of a suitable dose of this fluid into a glandered horse causes striking febril symptoms which do not occur in a healthy animal. Glanders, like tubercle, may exist in insidious latent forms which there was formerly no means of detecting, but which are at once disclosed by this means. If a glandered horse has been accidentally introduced into a large stable this method of diagnosis surely tells if it has infected others. All receive a little mallein. Those which become affected with fever are slaughtered, and thus not only is the disease prevented from spreading to other horses, but the grooms are protected from a mortal disorder.

This valuable resource sprang from Koch's work on tuberculin, which has also indirectly done good in other ways. His distinguished pupil, Behring, has expressly attributed to those researches the inspiration of the work which led him and his famous collaborateur, the Japanese Kitasato, to their surprising discovery of anti-toxic serum. They found that if an animal of a species liable to diphtheria or tetanus received a quantity of the respective toxin, so small as to be harmless, and afterwards, at suitable intervals, successively stronger and stronger doses, the creature, in course of time, acquired such a tolerance for the poison as to be able to receive with impunity a quantity very much greater than would at the outset have proved fatal. So far we have nothing more than seems to correspond with the effects of the increasingly potent cords in Pasteur's treatment of rabies. But what was entirely new in their results was that, if blood was drawn from an animal which had acquired this high degree of artificial immunity, and some of the clear fluid or serum which exuded from it after it had clotted was introduced under the skin of another animal, this second animal acquired a strong, though more transient, immunity against the particular toxin concerned. The serum in some way counteracted the toxin or was antitoxic. But, more than that, if some of the antitoxic serum was applied to an animal after it had already received a poisonous dose of the toxin it preserved the life of the creature, provided that too long a time had not elapsed after the poison was introduced. In other words, the antitoxin proved to be not only preventive but curative.

Similar results were afterwards obtained by Ehrlich, of Berlin, with some poisons not of bacterial origin, but derived from the vegetable kingdom; and quite recently the independent labors of Calmette, of

Lille, and Fraser, of Edinburgh, have shown that antidotes of wonderful efficacy against the venom of serpents may be procured on the same principle. Calmette has obtained antitoxin so powerful that a quantity of it only a 200,000th part of the weight of an animal will protect it perfectly against a dose of the secretion of the poison glands of the most venomous serpents known to exist, which, without such protection, would have proved fatal in four hours. For curative purposes larger quantities of the remedy are required, but cases have been already published by Calmette in which death appears to have been averted in the human subject by this treatment.

Behring's darling object was to discover means of curing tetanus and diphtheria in man. In tetanus the conditions are not favorable; because the specific bacilli lurk in the depths of the wound, and only declare their presence by symptoms caused by their toxin having been already in a greater or less amount diffused through the system; and in every case of this disease there must be a fear that the antidote may be applied too late to be useful. But in diphtheria the bacilli very early manifest their presence by the false membrane which they cause upon the throat, so that the antitoxin has a fair chance; and here we are justified in saying that Behring's object has been attained.

The problem, however, was by no means so simple as in the case of some mere chemical poison. However effectual the antitoxin might be against the toxin, if it left the bacilli intact, not only would repeated injections be required to maintain the transient immunity to the poison perpetually secreted by the microbes, but the bacilli might, by their growth and extension, cause obstruction of the respiratory passages.

Roux, however, whose name must always be mentioned with honor in relation to this subject, effectually disposed of this difficulty. He showed by experiments on animals that a diphtheritic false membrane, rapidly extending and accompanied by surrounding inflammation, was brought to a stand by the use of the antitoxin, and soon dropped off, leaving a healthy surface. Whatever be the explanation, the fact was thus established that the antitoxic serum, while it renders the toxin harmless, causes the microbe to languish and disappear.

No theoretical objection could now be urged against the treatment; and it has during the last two years been extensively tested in practice in various parts of the world, and it has gradually made its way more and more into the confidence of the profession. One important piece of evidence in its favor in this country is derived from the report of the six large hospitals under the management of the London Asylums Board. The medical officers of these hospitals at first naturally regarded the practice with scepticism, but as it appeared to be at least harmless they gave it a trial; and during the year 1895 it was very generally employed upon the 2,182 cases admitted, and they have all become convinced of its great value. In the nature of things, if the theory of the treatment is correct, the best results must be obtained when the patients are admitted at an early stage of the attack, before there has been time for much poisoning of the system, and accordingly we learn from the report that, comparing 1895 with 1894, during which latter year the ordinary treatment had been used, the percentage of mortality, in all the six hospitals combined, among the patients admitted on the first day of the disease, which in 1894 was 22.5, was only 4.6 in 1895; while for those admitted on the second day the numbers are 27 for 1894 and 14.8 for 1895. Thus for cases admitted on the first day the mortality was only one-fifth of what it was in the previous year, and for those entering on the second it was

halved. Unfortunately, in the low parts of London, which furnish most of these patients, the parents too often delay sending in the children till much later, so that on the average no less than 67.5 per cent. were admitted on the fourth day of the disease or later. Hence the aggregate statistics of all cases are not nearly so striking. Nevertheless, taking it altogether, the mortality in 1895 was less than had ever before been experienced in those hospitals. I should add that there was no reason to think that the disease was of a milder type than usual in 1895; and no change whatever was made in the treatment except as regards the antitoxic injections.

There is one piece of evidence recorded in the report which, though it is not concerned with high numbers, is well worthy of notice. It relates to a special institution to which convalescents from scarlet fever are sent from all the six hospitals. Such patients occasionally contract diphtheria, and when they do so the added disease has generally proved extremely fatal. In the five years preceding the introduction of the treatment with antitoxin the mortality from this cause had never been less than 50 per cent., and averaged on the whole 61.9 per cent. During 1895, under antitoxin, the deaths among the 119 patients of this class were only 7.5 per cent., or one-eighth of what had been previously experienced. This very striking result seems to be naturally explained by the fact that these patients being already in hospital when the diphtheria appeared, an unusually early opportunity was afforded for dealing with it.

There are certain cases of so malignant a character from the first that no treatment will probably ever be able to cope with them. But taking all cases together, it seems probable that Behring's hope that the mortality may be reduced to five per cent. will be fully realized when the public become alive to the paramount importance of having the treatment commenced at the outset of the disease.

There are many able workers in the field of bacteriology whose names time does not permit me to mention, and to whose important labors I cannot refer; and even those researches of which I have spoken have been, of course, most inadequately dealt with. I feel this especially with regard to Pasteur, whose work shines out more brightly the more his writings are perused.

I have lastly to bring before you a subject which, though not bacteriological, has intimate relations with bacteria. If a drop of blood is drawn from the finger by a prick with a needle and examined microscopically between two plates of glass, there are seen in it minute solid elements of two kinds, the one pale orange bi-concave discs, which, seen in mass, give the red color to the vital fluid, the other more or less granular spherical masses of the soft material called protoplasm, destitute of color, and therefore called the colorless or white corpuscles. It has been long known that if the microscope was placed at such a distance from a fire as to have the temperature of the human body, the white corpuscles might be seen to put out and retract little processes or pseudopodia, and by their means crawl over the surface of the glass, just like the extremely low forms of animal life termed, from this faculty of changing their form, amœbæ. It was a somewhat weird spectacle, that of seeing what had just before been constituents of our own blood moving about like independent creatures. Yet there was nothing in this inconsistent with what we knew of the fixed components of the animal frame. For example, the surface of a frog's tongue is covered with a layer of cells, each of which is provided with two or more lashing filaments or cilia, and those of all the cells acting in concert cause a constant flow of liquid in a definite direction over

the organ. If we gently scrape the surface of the animal's tongue we can detach some of these ciliated cells; and on examining them with the microscope in a drop of water we find that they will continue for an indefinite time their lashing movements, which are just as much living or vital in their character as the writhings of a worm. And, as I observed many years ago, these detached cells behave under the influence of a stimulus just like parts connected with the body, the movements of the cilia being excited to greater activity by gentle stimulation, and thrown into a state of temporary inactivity when the irritation was more severe. Thus each constituent element of our bodies may be regarded as in one sense an independent living being, though all work together in marvelous harmony for the good of the body politic. The independent movements of the white corpuscles outside the body were therefore not astonishing; but they long remained matters of mere curiosity. Much interest was called to them by the observation of the German pathologist Cohnheim that in some inflammatory conditions they passed through the pores in the walls of the finest blood vessels, and thus escaped into the interstices of the surrounding tissues. Cohnheim attributed their transit to the pressure of the blood. But why it was that, though larger than the red corpuscles, and containing a nucleus which the red ones have not, they alone passed through the pores of the vessels, or why it was that this emigration of the white corpuscles occurred abundantly in some inflammations and was absent in others, was quite unexplained.

These white corpuscles, however, have been invested with extraordinary new interest by the researches of the Russian naturalist and pathologist Metchnikoff. He observed that, after passing through the walls of the vessels, they not only crawl about like amœbæ, but, like them, receive nutritious materials into their soft bodies and digest them. It is thus that the effete materials of a tadpole's tail are got rid of; so that they play a most important part in the function of absorption.

But still more interesting observations followed. He found that a microscopic crutacean, a kind of water flea, was liable to be infested by a fungus which had exceedingly sharp-pointed spores. These were apt to penetrate the coats of the creature's intestine, and project into its body cavity. No sooner did this occur with any spore than it became surrounded by a group of the cells which are contained in the cavity of the body and correspond to the white corpuscles of our blood. These proceeded to attempt to devour the spore, and if they succeeded in every such case the animal was saved from the invasion of the parasite. But if the spores were more than could be disposed of by the devouring cells (phagocytes, as Metchnikoff termed them) the water flea succumbed.

Starting from this fundamental observation, he ascertained that the microbes of infective diseases are subject to this same process of devouring and digestion, carried on both by the white corpuscles and by cells that line the blood vessels. And by a long series of most beautiful researches he has, as it appears to me, firmly established the great truth that phagocytosis is the main defensive means possessed by the living body against the invasion of its microscopic foes. The power of the system to produce anti-toxic substances to counteract the poisons of microbes is undoubtedly in its own place of great importance. But in the large class of cases in which animals are naturally refractory to particular infective diseases the blood is not found to yield any antitoxic element by which the natural immunity can be accounted for. Here phagocytosis seems to be the sole defensive

agency. And even in cases in which the serum does possess antitoxic, or, as it would seem in some cases, germicidal properties, the bodies of the dead microbes must at last be got rid of by phagocytosis, and some recent observations would seem to indicate that the useful elements of the serum may be, in part at least, derived from the digestive juices of the phagocytes. If ever there was a romantic chapter in pathology, it has surely been that of the story of phagocytosis.

I was myself peculiarly interested by these observations of Metchnikoff's, because they seemed to me to afford clear explanation of the healing of wounds by first intention under circumstances before incomprehensible. This primary union was sometimes seen to take place in wounds treated with water-dressing, that is to say, a piece of wet lint covered with a layer of oiled silk to keep it moist. This, though cleanly when applied, was invariably putrid within twenty-four hours. The layer of blood between the cut surfaces was thus exposed at the outlet of the wound to a most potent septic focus. How was it prevented from putrefying, as it would have done under such influence if, instead of being between divided living tissues, it had been between plates of glass or other indifferent material? Pasteur's observations pushed the question a step further. It now was, How were the bacteria of putrefaction kept from propagating in the decomposable film? Metchnikoff's phagocytosis supplied the answer. The blood between the lips of the wound became rapidly peopled with phagocytes, which kept guard against the putrefactive microbes and seized them as they endeavored to enter.

If phagocytosis was ever able to cope with septic microbes in so concentrated and intense a form, it could hardly fail to deal effectually with them in the very mitigated condition in which they are present in the air. We are thus strongly confirmed in our conclusion that the atmospheric dust may safely be disregarded in our operations, and Metchnikoff' researches, while they have illumined the whole pathology of infective diseases, have beautifully completed the theory of antiseptic treatment in surgery.

I might have taken equally striking illustrations of my theme from other departments in which microbes play no part. In fact any attempt to speak of all that the art of healing has borrowed from science and contributed to it during the past half-century would involve a very extensive dissertation on pathology and therapeutics. I have culled specimens from a wide field; and I only hope that in bringing them before you I have not overstepped the bounds of what is fitting before a mixed company. For many of you my remarks can have had little if any novelty; for others they may perhaps possess some interest as showing that Medicine is no unworthy ally of the British Association; that, while her practice is ever more and more based on science, the ceaseless efforts of her votaries to improve what have been fittingly designated *Quæ prosunt omnibus artes* are ever adding largely to the sum of abstract knowledge.

JOSEPH LISTER.

THE BUFFALO MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SECTION G — BOTANY.

THE Botanical Section, G, of the A. A. A. S., held very successful sessions during the the meeting at Buffalo. Monday, the 24th of August at 11:40 a. m., the Section was organized and at 4:30 p. m., listened to the address of Vice-President, N. L. Britton on 'Botanical Gardens.' Tuesday, Wednesday and Thursday were devoted to the reading of papers and discussions. The papers were as follows:

The forces determining the positions of leaves: By R. N. Day.

Specimens of Phaseolus, Taraxacum, Cucurbita, Nicotiana, Helianthus and Arisæma were grown under the following conditions:

In darkness and in light.

a. Upright position.

b. Horizontal.

c. Inverted.

d. Horizontal or planostat.

Without discussion of the experimental details, it may be said that the conclusion of Vines that photo-epinasty does not exist is confirmed, and it is also concluded that epinasty and hyponasty are inherent properties whose reactions may be suppressed but whose general nature is not influenced by external conditions. Secondly, the results obtained bear directly on the recent conclusions of Vines and the current and accepted generalizations.

Vines' statement that dorsiventral organs are never apogeotropic is by no means substantiated, nor is it by any manner of reasoning to be inferred from the developmental history of the leaf. It might well be applied, however, to stems or flower structures. It may be seen from the author's and other results that dorsiventral leaves may be diaheliotropic, diageotropic or apogeotropic, epinastic or hyponastic. The factor determining the position of the leaf in every instance is the heliotropic tendency, which so far overbalances the influence of the other two forces that their reactions are suppressed. The position of the leaf then is a physiological, not a mechanical resultant, and may not be expressed by the parallelogram of forces as designed by Krabbe in 1889.

The bacterial flora of cheddar cheese: By H. L. Russell and John Weinzirl.

The study made by the author determines quantitatively and qualitatively the bacterial flora of our American cheddar cheese at the various phases of the ripening process. The first change from that in the milk is a diminution in number for the first ten days. In this the different species all suffer loss. Soon there begins an enormous development of organisms that is confined to lactic acid group of bacteria. The digesting and gas-producing bacteria gradually decrease in numbers. Succeeding this stage of bacterial increase is a period of gradual decline, which continues throughout the life of the cheese, until it is almost sterile in the course of a year or two. The physical changes that mark the curing of the cheese begin to appear synchronously with the marked development of lactic acid bacteria. The authors hold that these facts cannot be reconciled with the theory that the digesting bacteria are the active agents in the curing.

The pollen and stigma of Arisæma: By W. W. Rowlee.

The author described the andrœcium and gynœcium of *Arisæma triphyllum* and *A. Dracontium*. He noted the peculiarities of the consolidation of the stamens, the open style with the stigmatic hairs not only on the surface of the stigma, but also on the inner surface of the tube and forming a stigma like tuft on the inner surface of the ovary. The pollen in one case was found to have already germinated within the anthers, and the tubes had folded back and forth upon themselves. Other cases examined did not show the same growth.

Studies in nuclear phenomena, and the development of the ascospores in certain Pyrenomycetes: By Mary A. Nichols.

The results of the author's study point to the conclusion that a sexual process may be present in some members of the *Sphæriaceæ*, and absent or very degenerate in others. In *Ceratostoma brevirostre* the origin of the ascospore is distinctly traceable to a fusion of

differentiated gametes, while in *Teichospora* only possible rudiments of antheridia are present. The successive stages from the formation of the oosphere to the maturation of the ascospore reveal a process of development somewhat different from any heretofore suggested, but analogous to the development in *Sphærotheca*, described by Harper, and also somewhat similar to that in the *Florideæ*. The paper contains also an account of the discovery of nuclei in this family, their structure and behavior during division.

On the stem anatomy of the Onagraceæ: By FRANCIS RAMALEY.

As a result of the examination of specimens of seven genera of the tribe *Onagrariæ*, including thirteen species, the author found no marked anatomical specific or generic characters which could be used as a basis for classification.

Structures of the embryo-sac: By J. M COULTER.

The paper shows that the current statements concerning (1) egg apparatus, (2) primary endosperm cell and (3) antipodal cells should be modified as follows:

(1) *Egg apparatus:* two or three usually naked cells, the oosphere and one or two synergids, together representing a single archegonium, of which the synergids may represent canal cells.

(2) *Primary endosperm cell:* A cell formed by the fusion of two vegetative cells (the polar cells), which is stimulated normally by the act of fertilization to continue the vegetative development of the gametophyte, just as the adjacent sporophyte structures are stimulated to develop seed and fruit.

Antipodal cells: A group of cells, variable in number, evanescent or resistant; representing the vegetative region of the gametophyte not dependent for its development upon fertilization.

On Cratægus coccinea and its Segregates: By N. L. BRITTON.

The paper discussed the characters and distribution of *C. coccinea* and two probable varieties, *C. macracantha*, *C. rotundifolia* and *C. mollis* and was illustrated by specimens of all the forms described.

Notes on the genus Amelanchier: By N. L. BRITTON.

Specimens illustrating the five eastern species, *A. Canadensis*, *A. Botryapium*, *A. rotundifolia*, *A. spicata* and *A. oligocarpa*, were exhibited and their inter-relationships discussed.

Some Cyperaceæ new to North America, with remarks on other species: By N. L. BRITTON.

Record was made of seven species of sedges hitherto unknown to occur within United States, and specimens illustrating them were shown.

On the Cardamines of the C. hirsuta group: By N. L. BRITTON.

A discussion of the species *C. hirsuta*, *C. Pennsylvanica*, *C. flexuosa*, *C. parviflora* and *C. arenicola*, all of which were maintained as distinct. The paper was illustrated by specimens.

On the formation and distribution of abnormal resin ducts in Conifers: By ALEX. P. ANDERSON. The study shows that:

(1) Annual rings of *Pinus silvestris* and *Picea excelsa* containing frost rings have in cross sections fewer vertical resin ducts per sq. mm. than the normal rings.

(2) Regulatory tissue in hyponastic branches of *Pinus silvestris* has in cross sections fewer resin ducts per sq. mm. than the opposite side of the branch.

(3) In *Abies pectinata*, affected with *Æcidium elatinum*, the fungus mycelium is never found in the resin duct canals, nor in the epithelial cells surrounding the canals. Abnormal resin ducts are always found in

the wood of the thickened portion of the diseased branch.

(4) In *Pinus strobus* diseased at the root with *Agaricus melleus* an increase in the number of resin ducts of the wood takes place in the whole plant above the diseased part.

(5) In the wood of branches of *Abies pectinata* diseased with *Phoma abietina*, and in young seedlings of the same species, abnormal resin ducts are found only above the constricted portion of the branch.

An apparently undescribed Cassia from Mississippi: By C. L. Pollard.

This is a remarkable *Cassia*, allied to *C. chamæcrista*, but distinguishable by its virgate habit and strict pods, collected in northern Mississippi by S. M. Tracy. It proves, upon cultivation, to warrant its separation as a distinct species, for which the name *C. Tracyi* is proposed.

A discussion of the order Pesizineæ, Schröter: By E. J. Durand.

The author gave a brief history of the classification of the fleshy Discomycetes from the time of Linnæus, together with the ideas of modern systematists regarding the same plants. Especial attention was given to those of Schröter. The latter's views were discussed in the light of investigations, made by the author during the two years, touching the structure of these plants, illustrating the bases of their division into families.

A Bacterial Disease of the Squash-bug (Anasa tristis): By B. M. Duggar.

The author gave in brief the characters of a contagious disease first observed in a laboratory breeding cage. Many successful experiments were reported with both squash-bugs and young chinch-bugs. Isolation of the pathogenic *bacillus* and its growth on various nutrient media were described, likewise the microscopic characters and the distribution of the bacteria within the tissues of the host. Mention was also made of a toxic principle excreted by the organism, in an infusion of which many insects die almost immediately on immersion.

Grass flora of Iowa: By L. H. Pammel.

In the absence of the author the substance of the paper was given by J. M. Coulter.

Iowa lying between the two great rivers, respectively the Mississippi and Missouri, embraces an area of 56,025, it is well watered by its numerous streams and small lakes, all of which are intimately concerned in the distribution of plants. Among the streams are some of considerable size. About two-thirds of the State is drained by rivers that flow into the Mississippi and its tributaries. The largest wooded area is confined to the Mississippi and its tributaries. These wooded areas offer conditions that have greatly modified the distribution of grasses in this State. The country is not broken, but northeastern Iowa is extremely rugged. Along the Missouri occur the loess hills, with steep embankments and a loose friable soil. Concerning our grass flora the State is not greatly diversified. We have north, south, east, west, extra-continental and introduced species. In the number of species the State has less representatives than Nebraska on the west, than Illinois on the east and Missouri on the south. The southern indigenous types predominate, fellowed by northern. Only eleven of our species are typical western; thirteen are extra-continental, and fifty-five are introduced. Blue grass is the most abundant of our grasses. This is followed by *Phleum pratense*, introduced grass, and *Hordeum jubatum*, and *Elymus Canadensis*, followed by two typical Southern plants *Andropogon provincialis* and *Andropogon scoparius*.

A Contribution to our knowledge of the relation between growth and turgor: By Edwin B. Copeland.

An account was given of the state of turgor of seedlings of *Vicia faba* grown at various temperatures, and an explanation of the high turgor when growth is slow and *vice versa*. He concludes that the rapidity of growth regulates the amount of turgor present, rather than that the reverse is the case.

The relation between Thysanella and Polygonella as shown by a hitherto unobserved character: By JOHN K. SMALL.

The genus *Thysanella* has generally persistently and apparently without reason been referred to *Polygonum*. Besides ample characters in the habits and reproductive parts already recorded, the branching in *Polygonella* and *Thysanella* is internodal, and not nodal, as in all other members of *Polygonaceæ*.

An apparently undescribed species of Prunus from Connecticut: By JOHN K. SMALL.

A relative of *Prunus maritima* growing in the immediate neighborhood with it. The new species differs from the beach plum in habit, leaf form, flower and fruit.

The flora of the summits of King's Mountain and Crowder's Mountain, North Carolina: By JOHN K. SMALL.

Two isolated peaks with a moderate altitude harboring a local fern (*Asplenium Bradleyi*) and several members of the Alleghenian flora which we should not expect to find there. Their floras are shrubby, with the exception of two perennial herbs; one fern and a sedge, and about one-half the shrubs on King's Mountain are ericaceous. All the normally large forest trees occurring there are in the form of small shrubs ranging from three to six feet in height.

Rheotropism and the relation of response to stimulus: By F. C. NEWCOMBE.

Rheotropism is the change in direction of movement or of growth of an organism, induced by flowing water as a stimulus. Those organs or organisms that move or bend against the stream are *positively rheotropic*, while those moving in the same direction with the stream are *negatively rheotropic*.

It is now shown that the roots of many plants are positively rheotropic, while the roots of others are non-responsive. Moreover, the phenomena are marked by characters indicating irritability, since there is a latent period preceding the response and an after-effect following the stimulus.

We need not necessarily assume that the response shows a close biological relation to the stimulus used, since it is certain that in some cases the causal mechanism connecting stimulus and response may be set in motion by stimuli which are not the usual stimuli calling forth the response.

Some adaptations of shore plants to respiration: By HERMANN VON SCHRENK.

A large number of plants growing on the borders of ponds and rivers have developed structures adapting them to more or less aquatic conditions. These modifications are of two kinds, either the development of a mass of spongy tissue ærenchyma or the formation of very much enlarged lenticels, termed water lenticels. *Decodon verticillata* may serve as an example of the first. This plant always develops ærenchyma when growing in water. A few cases have been observed where the plant grew in drained ponds, and in those cases no ærenchyma was present. It seems to be well proved that this tissue is simply for respiratory purposes. *Sambucus canadensis* illustrates the second class. It has a large number of water lenticels developed at its base. These structures, however, are not always present. The same is true of a large number of plants which can grow as well in dry and moist localities.

On the roots of a number of plants, such as *Bidens connata* or *Eupatorium perfoliatum*, etc., structures occur similar to water lenticels which serve the purpose of aëration.

They are found on roots growing near the surface and in great numbers, especially in very damp soil. In development they differ from ordinary lenticels, owing to absence of initial stomata. Plants growing in similar localities, such as *Impatiens fulva*, *Myrica gale*, etc., never show such adaptation. The question arises as to the significance of these changes, which appear to be constant in the cases mentioned, and experiments on plants grown in water may serve toward solving the question.

A comparison of the flora of Erie Co., Ohio, with that of Erie Co., N. Y.: By E. L. Moseley.

Though both counties are adjacent, the Ohio district, so far as now known, contains 265 native species of phanerogams, not known to occur within 50 miles of Buffalo. The causes are said to be mainly climatic, the average date of the last killing frost in spring at Sandusky being April 30th, at Buffalo May 20th; and the first frost in autumn at Buffalo being September 15th, at Sandusky October 24th. One of the causes of the later spring at Buffalo is the blowing of the ice to the east end of the lake.

Sporophyll-transformation in dimorphic ferns: By Geo. F. Atkinson.

The author detailed the results of experiments conducted on *Onoclea sensibilis* and *O. struthiopteris*, showing that cutting off the vegetative leaves in the middle of May and again in June would cause the partial or complete transformation of the young sporophylls to vegetative leaves. The paper was illustrated by lantern views.

The significance of the compound ovary: By Charles E. Bessey.

In the study of the gynœcium of Angiosperms we are forced to conclude that its primitive condition was apocarpous — in other words, that whether monocarpic or polycarpic there was at least no union of ovary with ovary. The original ovary was doubtless simple.

By a comparative study of the ovaries of existing plants we are led to the conclusion that the syncarpous gynœcium was derived from the apocarpous gynœcium. This is so plain that it is needless to dwell upon it. Both phylogenesis and ontogenesis furnish us with numerous illustrations of the truth of this statement.

It is to be observed that the compound ovary is a comparatively stable structure, and that it changes slowly within any natural group, or in passing from group to group. No part of the plant is more stable. Yet with all its stability it undergoes changes in certain directions. It is a common occurrence to find a pentacarpellary ovary reduced to four, three, or two carpels, and this may proceed until, as in some of the Caryophyllaceæ, we seem to have but one carpel remaining. In rare cases there appears to be a reversion from syncarpy towards apocarpy, as in the Apocynaceæ and Asclepiadaceæ, but as a rule it may be said that syncarpy once attained by a group is persistently maintained, however much of simplification it may otherwise have undergone.

The ultimate development of the compound ovary is in the direction of a simplification of structure. Thus the many carpels of most Thalamifloræ and Heteromoræ are gradually reduced to the two carpels of the Bicarpellatæ. In the Calycifloræ the Rosales and Myrtales have generally several to many carpels, while in the Umbellales there are but two. Likewise in Inferæ the ovary in the lower group, Rubiales, have more carpels than we find in the highest group, Asterales. A similar simplification occurs in the Monocotyledons, as we pass from the Caronarieæ to the sedges and grasses.

This simplification of structure results in increased parental care of offspring. Thus

while many embryos are to be nourished in the earlier cases, there are but one or two in the later. The biological significance of this result is so well known as to need no discussion here.

When we come to an application of what we know of the compound ovary to systematic botany, it appears to me that the following conclusions are warranted:

(a) The apocarpous plants are to be regarded as lower than those which are syncarpous, and in a natural arrangement the former must precede the latter.

(b) We must carefully distinguish between ovaries which are primitively simple and those which have become simplified from a more complex structure. In these cases the first indicate a lower and the second a higher position in the natural system.

(c) Grasses, Sedges, etc., in which the ovaries are simplified from the compound type are not the lowest of the Monocotyledons.

(d) Willows, Oaks, Walnuts, etc., with their apparently simple flower structure, are not to be regarded as among the lowest of the Dicotyledons.

The influence of rainfall upon leaves: By D. T. MACDOUGAL.

The first recognition of the influence of rainfall upon leaf forms was that given by Ridley in his Flora of Rajang, and an exploitation of the subject was made by Stahl* in 1893. Since the publication of Stahl's work, Jungner has carried on a great amount of observational work of doubtful value and has made some attempts to produce rainfall characters in leaves experimentally. The rainfall characters of leaves recognized by these workers are as follows: Attenuated apices, entire margins, glossy appearance of the upper surface of the laminæ, coupled with a ready adhesion of water; deepened furrows above ribs, pendant positions of the laminæ and enlargement of the pulvini. It is to be noted, of course, that in no one species do all of the above characters appear, and furthermore that only a few of those named have been induced in leaves experimentally. Jungner was able to cause the glossy appearance of the upper surface of the laminæ and its adhesion to water, and a pendant position of the entire leaf in a few plants by experimental methods.

*Ann. d. Jard, bot. d. Bintenzorg, 1893.

The curvature of tendrils: By D. T. MACDOUGAL.

The curvature of tendrils in response to a contact stimulus is due to the contraction of certain cells on the concave side of the organ. These cells show great specialization in form, size and arrangement, and are markedly different from similar elements on the convex side. The protoplasm of the external cells exhibits some specializations and appears to correspond in density with the degree of sensitiveness. It has been found that the effects of a stimulus are not transmitted more than two centimeters from the point of its reception. The prevalent idea that the coiling of the free portion of a tendril is stimulated by the engagement of the tip with any solid object is found to be false, since the curvature of the organ in response to a stimulus and the coiling of the free portion are entirely independent processes; the latter ensues on maturity only, as may be seen if the tip of a young tendril is attached to a support.

Relation of the growth of leaves to the carbon dioxide of the air: By D. T. MACDOUGAL.

A large number of experiments were performed in which leaves of *Arisæma triphyllum*, *Calla palustris*, *Lilium splendidum*, *Trillium erectum* and *T. erythrocorpum*, *Isopyrum biternatum*, *Oxalis floribunda* and *O. vespertilionis*, *Justicea* sp. *Hibiscus rosa-sinensis*, *Zea mais* and *Phœnix dactylifera* were allowed to

develop under conditions of functional inactivity in light and in darkness. The amount of development or existence which can be carried on by the leaves of any of these species will depend on the 'availability' of the stored food. Ordinarily the leaf depends on its own activity for a portion of the material used for constructive purposes. Many of the leaves die when inactive in light, due to an insufficient food supply, and the disintegration of the chlorophyll is a result not a cause of the death.

The removal of concurrent members has a different effect on the remaining member when in light from that in darkness, a fact due in part to the intervention of the regulatory processes attendant on this condition.

In a series of experiments in my own laboratory, in which specimens of *Arisæma triphyllum*, *Trillium erectum* and *T. recurvatum* were subjected to a continuous spray of water for a period of 10 to 20 days, the author was able to produce the characters obtained by Jungner and also the additional one of diminution of the marginal teeth and deepening of the furrows above the ribs. In leaves of *Arisæma* the laminæ assumed an upwardly convexed form not to be confused with the rolling and twisting of leaves when subjected to abnormally cold water, and which is undoubtedly a new rainfall character.

It was found that the glossy appearance of the 'rain' leaves was due to the flattening of the outwardly convexed papillose ends of the epidermal cells of the upper side of the lamina, with a possibility of accompanying chemical changes in the character of the outer walls.

A comparative study of the development of some anthracnoses in artificial cultures: By Bertha Stoneman.

Seven different species of *Gloeosporium* and *Calletotrichum* and the allied genera *Vermicularia* and *Volutella* present in artificial cultures distinct characters varying to a certain extent with varying conditions of light, temperature and nutrient media. Under uniform conditions of growth the characters have been found sufficiently constant to be of value in distinguishing or uniting species whose similarity in morphological structure or variations resulting from the character of the host would render their systematic position uncertain. Of about thirty species studied, five (three *Colletotrichum* and 2 *Gloeosporium*), have been definitely connected with an ascigerous form; the transition from one stage to the other occurring without the intervention of a pycnidial stage. The ascigerous stages of each, two of which have been found as saprophytes in nature, bear a close resemblance to each other, and would fall in a genus near *Gnomomella*.

The habitats of the rarer ferns of Alabama: By L. M. Underwood.

A brief account of visits to Winston county, the type locality of *Trichomanes petersii*, was given, with some account of the habit of growth of that rare fern; also to Havana Glen, where *Asplenium ebenoides* grows in considerable abundance. This fern, which has been regarded as a hybrid, is shown by its habit to be a species entirely distinct from either of its supposed parents. The Southern fern-ally for a long time considered as a variety of *Botrychium ternatum*, is shown to be an entirely distinct species in form, habit and time of producing spores as originally shown by Lamarck.

Notes on the allies of the sessile Trillium: By L. M. Underwood.

Several species have been confused under this group name. Even Linnæus confused two species in the original description of *Trillium sessile*. One of these, an Alabama species figured by Catesby, was exhibited and attention was called to its value as an ornamental plant.

The Distribution of the Species of Gymnosporangium in the South: By L. M. UNDERWOOD and F. S. EARLE.

The distribution of the six species of *Gymnosporangium* parasitic on *Juniperus virginiana* was noted. An undescribed species was announced as most common in Alabama aside from *G. macropus* and *G. clavipes*.

Notes on the Pine-inhabiting Species of Peridermum: By L. M. UNDERWOOD and F. S. EARLE.

A revision of the species of the eastern United States, which number gives characters, distribution and hosts. The different character of the swellings produced by *Peridermum cerebrum* on *Pinus Tæda* and *Pinus echinata* were exhibited, the former with fusiform and the latter with globose swellings on twigs, branches or even trunks. The species produces much damage in some portions of the South.

The Terminology of Reproduction and of Reproductive Organs: By C. R. BARNES.

The speaker discussed first the distinction between vegetative and non-sexual reproduction. The reproduction of the earliest plants was undoubtedly vegetative reproduction. Non-sexual reproduction is not fairly differentiated from it until the *Bryophyta* are reached, and with them a clear alternation of generations. In *Bryophyta*, *Pteridophyta* and *Spermatophyta* the forms of vegetative reproduction, viz., by broodbuds, or gemmæ, by detached shoots and by proliferation (with detachment late when it occurs at all) are clearly distinguished from the non-sexual form, viz., by spores produced in a compound sporangium. The fundamental distinction lies in this, that vegetative reproduction *repeats the same phase*, while non-sexual reproduction *gives rise to the alternate phase*.

In the second topic discussed the classification of sporangia and gametangia into *simple* and *compound* was suggested. The simple gametangium or sporangium is one consisting of a single cell, whose contents become respectively the gametes or spores.

The compound gametangium or sporangium is an aggregate of several or many (rarely reduced to one) simple gametangia or sporangia surrounded by one or more layers of sterile protection cells. Oogonia and carpogonia are simple; archegonia are compound gametangia. Simple sporangia occur below the *Bryophyta*; compound in *Bryophyta* and above.

What is the Bark? By C. R. BARNES.

Attention was called to the varying use of this term by different botanists. The Germans use *Borke* and *Rinde* to denote respectively the external tissue of the root or stem which dries up, and the entire mass of tissue outside the cambium. In this they are followed by the English. The American usage, except as modified by foreign influence, assigns the name bark to the entire mass of tissue outside the cambium. In this use they are followed by the French, and the author advocated the use of bark in this sense, and cortex to designate certain parts of the bark, indicated by a preceding adjective.

The Development of the Vascular Elements in the Primary Root of the Indian Corn: By W. W. ROWLEE.

As a result of the author's investigation he finds that the large cells in the central portion of the root tip, which are usually stated to give rise to the vessels, pass over into parenchyma and that the first vessels are differentiated from cells nearer the surface.

Remarks on Chalazogamy: By J. M. COULTER.

In this paper the author considered: (1) Chalazogamy as a basis of classification. It was used at first by Treub in 1891. As the basis of grouping all angiosperms, chalazogams and parogams. It proves to be of no value even in the most minor classifica-

tions. (2) Chalazogamy as an indication of phylogeny. Nawaschin has maintained that chalazogamy is a transition stage between gymnosperms and angiosperms, in which the pollen tube seeks to adapt itself gradually to traversing cavities. Adaptation to cavities is shown by the author of this paper to be largely unnecessary, and chalazogamy gives no more suggestion of gymnosperms.

Ceres-pulver; Jensen's new fungicide for the treatment of smuts: By W. A. Kellerman.

The speaker gave an account of the above. The material consists of Potassium sulphide, to which are added in small quantity some other ingredients, regarded as important by Jensen. A solution of two pounds in 125 liters of water is poured on the grain, the latter being stirred thoroughly in the meantime. This fungicide is found by Jensen to be effectual in case of oat smut and barley smut. Prof. Kellerman has the past season tested the ceres-pulver, and corroborates Jensen's claim. He also stated that Jensen has recently published the fact that the experiments made in 1890 by himself and Mr. Swingle and reported in a bulletin of the Kansas Experiment Station, were the 'starting point' for the ceres-pulver. These experiments showed that potassium sulphide was an efficient fungicide for these smuts. The hot-water treatment has no superior, but farmers do not use it. Prof. Kellerman, therefore, recommends the use of ceres-pulver, and also of potassium sulphide.

Parthenogenesis in Thalictrum fendleri: By David F. Day.

In August, 1883, the author found in one of the cañons of Pike's Peak, Colorado, a seedling specimen of Thalictrum fendleri, and the plant was sent home for cultivation. The plant bore only pistillate flowers and matured seed. These seeds were the following year planted, and, in the judgment of the author, with no possibility of pollination, since there were no staminate plants, seed was matured. These results have been obtained for several successive years, and the phenomenon is regarded as an example of parthenogenesis.

What should constitute a type-specimen? By S. M. Tracy.

The speaker called attention to the want of uniformity in the term 'type,' 'duplicate of type,' 'co-type,' etc., and urges the necessity for the adoption of some uniform method of expression.

Remarks on the northern species of Vitis: By L. H. Bailey.

A discussion of the systematic position of certain native grapes. (In the absence of the author, read by title.)

The point of divergence of Monocotyledons and Diocotyledons: By Charles E. Bessey.

In discussing this question the speaker assumed that it is unnecessary to bring forward proofs as to the common origin of the two sub-classes, Monocotyledonæ and Dicotyledonæ. It is possible, but in his opinion improbable, that some plants are now included in them which have had an independent origin, but all will agree that after making the most liberal subtractions possible the two sub-classes must still remain as two very closely related groups, with essentially the characters now assigned to them.

We must bear in mind the well-known biological law that in general the relationship of allied groups is most marked between their lower members, that is, between those members which represent the primitive types, and that it is less marked between the higher members of the groups.

In other words, we recognize the fact that groups diverge as they are evolved. If we represent the phylogenesis of plants by lines we are compelled to arrange these lines so that they show repeated series of divergencies.

Another law which must be kept in mind, also, is that evolution for the most part has proceeded from the simple to the complex. The simpler plants of to-day represent to a large extent the types of the primitive plants of former periods, from which the complex plants of to-day were derived. In this connection, however, we must not overlook the fact, as pointed out elsewhere,* that in the evolution of the successive members of groups of plants there has often been a simplification of structure. Thus we often find apetalous derivatives from polypetalous types; bicarpellary ovaries from polycarpellary types; one-celled, one-seeded, compound ovaries from several-celled, many-seeded ovaries. But there is a great difference between these simplified structures, which have been derived from more complex structures, and those which are primitively simple. The former are nearer the end of a lengthened genetic line; the latter are nearer its beginning.

When we apply these principles to the system to Bentham and Hooker we find no contact points whatever between Monocotyledons and Dicotyledons. The lower Monocotyledons are very unlike any of the Apetalæ. What similarity, for example, is there between the Grasses and Sedges on the one hand, and the Oak, Walnut and Plane Trees on the other. It is only when we pass up to the *Apocarpæ in the Monocotyledons*, and to the *Micrembryeæ* and possibly *Piperaceæ* of the latter, there are many similarities of structure. To this reference must be made later, and it need only be said here that evidently the authors made no attempt to indicate by their arrangement of families any contact point between the Monocotyledons and Dicotyledons.

In the system of Engler and Prantl one might look for such a disposition of the families of the two sub-classes as to indicate a common point of origin, but in this we are disappointed. When we compare the structure of the families placed at the beginning of the Monocotyledons, viz: the *Typhaceæ*, *Pandanaceæ*, *Sparganiaceæ*, *Potamogetonaceæ*, *Naiadaceæ*, *Aponogetonaceæ*, *Alismaceæ*, etc., with those occupying a similar place in the Dicotyledons, viz: *Saururaceæ*, *Piperaceæ*, *Chloranthaceæ*, *Lacistemaceæ*, *Juglandaceæ*, *Myricaceæ*, *Leitneriaceæ*, *Salicaceæ*, etc., it is at once evident that here there is a great gulf between the two sub-classes. It is becoming more and more evident that this system, which promised so much, is little better as an expression of genetic relationship than the system of Bentham and Hooker, which it is now displacing. Its so-called lower families are for the most part composed of plants with not a simple, that is, a primitive structure, but a simplified structure. As a rational system, designed to express our ideas of genetic relationship, it is sadly disappointing.

It is evident that we must cease to confuse the simplified with the primitively simple structures, and that in the latter alone can we find the point of divergence of the plants of the two sub-classes under consideration. It is only when we do this that we are able to construct a system which shall suggest to us the solution of the problem. Our system must begin with simple pistils, not compound pistils—with really simple and simplified pistils. It matters little whether the flowers are perfect or not; whether they have many or few flowers-leaves, or even none at all. We have learned that these are minor matters, and that they change very readily even within narrow limits.

In accordance with these principles we may readily fix upon the apocarpous Monocotyledons (Bentham and Hooker's *Apocarpæ*) as the representatives of the primitive members of this sub-class. This struc-

* 'Evolution and Classification,' Proc. A. A. A. S., Vol. XLII., and 'The Significance of the Compound Ovary,' presented at this meeting.

ture will readily suggest the *Ranales* among the Thalamifloral Dicotyledons, and a closer examination shows a remarkable similarity of structure in not only the reproductive, but also in the vegetative organs of the plants of these two groups. After some years of study given to a comparison of these groups the author is more firmly convinced than ever of their genetic relationship. They show their relationship in their gross anatomy, the histology of their tissues and their embryology.

Allied to the *Ranales* are the *Rosales*, beginning with the Ranunculus-like *Potentilleæ*, and passing by easy steps to the simpler *Leguminosæ* on the one hand (*Cæsalpiniaceæ* and *Mimosaceæ*), and the *Saxifragaceæ* on the other, and through the latter to *Celastrales* and *Myrtales*.

Here then, in the author's opinion, is the point of divergence of the Monocotyledons and Dicotyledons, represented by the Apocarpæ of the former, and the *Ranales* and *Rosales* of the latter. The similarities in structure between some *Macrospermæ* and the *Naiadaceæ* in Bentham and Hooker's system, noticed above, as between some of the families (*Naiadaceæ*, *Alismaceæ*, *Chloranthaceæ*, etc.), placed by Engler and Prantl at the beginning of the two sub-classes, are hints as to a natural arrangement, which it is strange that these eminent systematists overlooked.

The development of the cystocarp of Griffithsia bornetiana: By Anna Arma Smith.

The development of the cystocarp of *Griffiithsia bornetiana* was described, and it was shown to agree in the main with that in *G. corallina* as described by Janczewski, except only one peripheral cell bears a carpogenic branch. The spores arise from a cell cut off from the supporting cell of the carpogenic branch after fertilization, the influence of which is transmitted, apparently, through the cells of the carpogenic branch. Since the paper was published in the July number of the *Botanical Gazette*, and because of the author's absence, it was read by title.

Morphology of the canna flower: By L. H. Bailey.

The speaker called attention to the prevailing asymmetry in the Scitamineæ, and remarked that groups of plants which show marked irregularities in forms are nearly always fertile subjects for plant-breeding. The most nearly symmetrical flowers of this order are found in the banana tribe, in which 5 stamens are present and the 6th is represented by a sterile filament. He exhibited a banana fruit to show its 5-angled form, and remarked that it is probable that somewhere in its phylogeny this fruit had lost its symmetry. He also called attention to the three seedless loculi of the fruit, and remarked that, although the plant is seedless, it still varies or it is the subject of evolution, thus discrediting Weismann's hypothesis that all progressive or permanent variation arises through sexual union.

In the ginger tribe the stamen is reduced to one normal member. In the canna tribe the stamen is presented by what is apparently but a single loculus of the anther, the other loculus being apparently developed into a foliaceous organ. The remaining stamens are represented by petal-like staminodia, and these members make up the showy part of the flower. The speaker exhibited specimens of canna flowers, and also charts, to show the very marked evolution in the form and size of the flower, and more especially of the staminodia, and the gradual increase in the size of the petal-like appendage of the one fertile stamen. There seems to be a considerable decrease in seed-production in the modern cannas as compared with the types of a generation and more ago, and this decrease is probably associated with less pollen, or less efficient pollen, in the modern flowers. This ten-

dency toward seedlessness is seen in many cultivated plants, of which the potato is a good example. Since new varieties come mostly from seeds, many persons have supposed that plant-breeding must eventually cease in these plants; but the speaker pointed out that the constant choice of seeds for sowing is itself a powerful agent in conserving the seed-producing power of the plant. So long as we select seeds, so long we may expect the effects of this selection to give seeds in at least a part of the individuals of every generation.

Distribution of plants on fresh-water islands: By CONWAY MACMILLAN.

The islands in Lake of the Woods were selected for study and description, and, after a general account of the geology and physiography of this body of water and its surroundings, a classification of islands was proposed as follows: 1. Floating bog islands; 2. Scirpus-bar islands; 3. Sand-dune islands; 4. Irregular rock islands; 5. Dome-shaped rock islands.

The paper proposed a classification of strand plants and surf plants, and laid particular stress upon an interesting zonal distribution of plants which characterized the dome-shaped islands. In these it was shown that an outer ring of shrub was succeeded towards the center by a zone of trees, an inner zone of shrub and a central meadow or shrub. This distribution was explained as resulting from the silting off of soil, until a thicker ring of soil was formed at the periphery of the islands.

The paper was illustrated by fifty lantern slides, showing island landscapes and calculated to bring out the points made concerning strand plants and zonal distribution, together with views of islands in which irregularity of surface prevented zonal and promoted crevice distribution.

GEO. F. ATKINSON,
Secretary.

CORNELL UNIVERSITY

THE THIRD SUMMER MEETING OF THE AMERICAN MATHEMATICAL SOCIETY.

THE Third Summer Meeting of the American Mathematical Society was held in the lecture hall of the Buffalo Society of Natural Sciences, at Buffalo, N. Y., on August 31st and September 1st. Among those present were:

Dr. E. M. Blake, Prof. M. Bôcher, Mr. J. M. Brooks, Prof. F. N. Cole, Prof. J. E. Davies, Prof. A. T. DeLury, Prof. E. W. Davis, Dr. L. E. Dickson, Prof. W. P. Durfee, Prof. H. T. Eddy, Prof. T. S. Fiske, Miss Ida Griffiths, Dr. G. W. Hill, Dr. J. E. Hill, Dr. J. I. Hutchinson, Prof. E. W. Hyde, Prof. T. F. Holgote, Mr. P. A. Lambert, Dr. G. H. Ling, Prof. J. McMahon, Prof. M. Merriman, Prof. E. H. Moore, Prof. W. F. Osgood, Prof J. P. Pierpont, Dr. V. Snyder, Mr. W. M. Strong, Prof. O. Schmiedel, Prof. L. G. Weld, Prof. H. S. White, Prof. C. B. Williams, Miss E. C. Williams, Miss M. F. Winston, Prof. F. S. Woods and Prof. A. Ziwet.

The President, Dr. G. W. Hill, occupied the chair. Two sessions were held each day, beginning respectively at 10 a. m., and 2:30 p. m. The following papers were read:

1. *Methods of defining monogenic functions.* DR. E. M. BLAKE.
2. *An existence theorem for a class of linear euthymorphic functions of a single variable.* DR. E. M. BLAKE.
3. *A geometric method for the study of uniform convergence and certain double limits.* PROF. W. F. OSGOOD.
4. *Non-uniform convergence and the integration of series term by term.* PROF. W. F. OSGOOD.
5. *Two triply-infinite systems of simple groups.* DR. L. E. DICKSON.
6. *Ternray algebras.* PROF. J. B. SHAW.
7. *The geometry upon three surfaces of the seventh order.* DR. J. E. HILL.
8. *A special form of a quartic surface.* DR. J. I. HUTCHINSON.
9. *Note on the integral and integro-geometric series.* PROF. E. D. ROE.
10. *The cross ratio group of n! (n–3)–ic Cremona transportations of flat space of n–3 dimensions.* PROF. E. H. MOORE.
11. *Criteria for the reality of nodes in Dupin's cyclides, with a corresponding classification.* DR. V. SNYDER.
12. *Numerically regular reticulations upon surfaces of deficiency higher than 1.* PROF. H. S. WHITE.
13. *Loci of the equations* $p=\varphi^x e$ *and* $p=\phi^x\psi^y e$ PROF. E. W. HYDE.

14. *On the hypothesis of the successive transmission of gravity and the possible perturbative effect on the earth's orbit.* PROF. J. MCMAHON.
15. *The continuity of chance.* PROF. E. W. DAVIS.
16. *A method of finding without a table the number corresponding to a given logarithm.* DR. ARTEMAS MARTIN.
17. *Table giving the first forty roots of the Bessel equation* $J_0(x)=0$, *and the corresponding values of* $J_1(x)$ PROF. B. O. PEIRCE and MR. R. W. WILSON.
18. *On the projective group.* PROF. H. TABER.

Dr. Blake's first paper gave a classification of the methods which have been used for defining monogenic functions, with example, references and historical notes. His second paper contained a demonstration of the existence of monogenic functions satisfying a relation which had presented itself as a greatly generalized form of the addition theorem of elliptic functions.

Prof. Osgood's first paper gave a geometric method, consisting in the study of the approximation of curves $y=S_n(x)$, for discussing the manner in which $S_n(x)$ converges (uniformly or non-uniformly) toward its limit $f(x)$ when $n=\infty$. Applications were made to the allied problems in double-limits of integrating and differentiating a series term by term. Numerous examples served as illustrations. His second paper studied the most general manner of the convergence of $S_n(x)$ toward its limit $f(x)$, where $S_n(x)$, $f(x)$ are continuous functions, and treated the problem of determining when

$$\int_{x_0}^{x} f(x)\,dx=\lim_{n=\infty}\int_{x_0}^{x} S_n(x)dx.$$

Broader sufficient conditions than those generally known for the integration of a series of continuous functions term by term were obtained. The former of these papers will appear in the *Bulletin of the American Mathematical Society* and the latter in the *American Journal of Mathematics*.

Jordon's decomposition of the general linear group on m indices, and of the group of Abelian substitutions on $2m$ indices, leads to two doubly-infinite systems of simple groups. By generalizing to the Galois field of order p^n, p being prime, Dr. Dickson reaches two systems of simple groups whose orders depend on three independent parameters m, n and p. His paper is intended for the *Annals of Mathematics*.

Prof. Shaw considered, in his paper, all the algebras in which three independent units occur. Dr. Hill used the general cubo-cubic transformation in three cases where the principal systems of the two spaces degenerate, to pass from a general cubic surface to a septic surface. In the first case the surface is distinguished by three triple and three double lines; in the second by a triple line and a double quintic, and in the third by a triple conic and a double quartic of the second kind. The quartic surface discussed in Dr. Hutchinson's paper is the locus of the vertex of a cone of the second order passing through six given points. If these six points be in involution on the twisted cubic through them, the coordinates of a point of the surface can be expressed in terms of elliptic functions. The object of Prof. Roe's paper was to obtain general formulæ for the summation of the integral and integro-geometric series.

All the cross-ratios of n quantities are expressible rationally in terms of any $n-3$ independent ratios. Starting with a certain such system of $n-3$ rations, and permuting the quantities one obtains in all $n!$ systems of the same type. The expression of these $n!$ systems in terms of any one leads to the group studied in Prof. Moore's paper. For $n=4$ it is the well-known group of six linear practical substitutions generated by $\lambda'=1/\lambda$, $\lambda'=1-\lambda$. For $n\geq 5$ it is holoedrically isomorphic to the symmetric group in n letters. It contains a sub-group of $(n-1)!$ collineations permuting amongst themselves certain $n-1$ fundamental points, and first given by Klein. Prof. Moore's group results from extending that of Prof. Klein by an

'inversion' having $n-2$ of the fundamental points as critical points and the remaining one as a fixed point. This paper is intended for the *Mathematische Annalen*.

In Dr. Snyder's paper Lie's haxaspherical coordinates were employed to define, without the use of line-geometry, a Dupin's cyclide. By associating the three simultaneous linear equations of definition with the point-complex and the plane-complex, one obtains determinants the signs of which indicate the reality of spheres common to the four complexes and thus show the presence of nodes. Dr. Snyder's paper will appear in the *Annals of Mathematics*.

On a convex surface of deficiency zero Euler's equation, together with the requirement of numerical regularity, gives three sets of integers for vertices, faces and edges of a polyedron. These by duality become five, corresponding to the five regular polyedra. On a surface of deficiency greater than unity the modified equation of Euler, together with similar limitations, gives again a finite number of sets of integers for vertices, faces and edges. These sets are of two sorts: 'derivative,' obtained from sets belonging to lower deficiencies; and 'special,' not so obtainable, but peculiar to the deficiency in question. These sets of characteristic numbers can be realized on concrete models. Prof. White discussed the subject in detail and exhibited models, constructed by Mr. O. H. Basquin, for deficiency 2 and for the 'special' sets of deficiency 3. For deficiency 2 there were 13 card models and 6 of plaster; for deficiency 3 there were 7 card models. Prof. White's paper will appear in the *Bulletin of the American Mathematical Society*.

In Prof. Hyde's paper, which is intended for the *Annals of Mathematics*, p is a variable point, e is a fixed point, x and y are scalars varying from $-\infty$ to $+\infty$, and φ and ψ are linear points, functions of the form:

$$\phi q = \Sigma (A_k e_k . e_k \mid q) , \quad \psi q = \Sigma (B_k e_k . e_k \mid q).$$

The curve and surface represented by the equations given in the title of the paper are studied, and many interesting properties which they possess are described.

In Prof. McMahon's paper, also intended for the *Annals of Mathematics*, the sun is assumed to move in a straight line with constant velocity, which is shared by the whole solar system; and the gravitational influence is supposed to issue from the sun in waves that move outward with constant velocity (equals, perhaps, to that of light). When any wave reaches the earth the latter is attracted towards the wave center, or point of space from which the wave issued. This effective center of acceleration is at a distance from the sun which varies between the limits $ka\ (1-e)$ and $ka\ (1+e)$, where k is the ratio of the velocity of the sun to that of gravitation, a is the semi-axis major of the earth's orbit, and e the eccentricity. Thus the orbit of the earth relatively to the sun is that which would be due to a center of force that performs small oscillations about its mean position. The law of this oscillatory motion is first determined, and then the equations of acceleration of the earth in its orbit, along and perpendicular to the radius-vector, are corrected for this small disturbance; and appropriate solutions of these differential equations are given, correct as far as terms in ke^2. The most important perturbative terms are examined, and their effect on the orbit determined.

Prof. Davis maintained that there existed a necessary and intimate association between the notions of continuity and chance. His paper will be published in the *Nebraska University Studies*. Dr. Martin's paper contained several series suitable for calculating a number when its logarithm is given. He intends to publish the paper in the *Mathematical Magazine*.

The first ten values of x, for which Bessel's function of the zeroth order $J_0(x)$ vanishes, were given to ten places of decimals

by Meissel. The next thirty roots of the equation $J_0(x)=o$, and the values of $J_1(x)$ corresponding to the first forty roots, have just been computed by Prof. B. O. Peirce and Mr. R. W. Willson by means of Vega's ten place table of logarithms, except in the few cases where a greater number of places was necessary, and then recourse was had to Thoman's tables. The computation has been done twice.

The total number of papers read was greater by two than the number read at last year's summer meeting. The attendance was the same as last year. The Council announced that the regular October meeting of the Society would be replaced by a special meeting to be held at Princeton, on October 17th, in honor of Profs. Felix Klein and J. J. Thomson, who would be in Princeton at that time as delegates to sesquicentennial celebration of Princeton University.

Thomas S. Fiske.
Columbia University.

A CURVE-TRACING TOP.

Some time ago I constructed a top (since called the gyrograph) for directly mapping out the curves corresponding to the precessional and progressive motion of a spinning body. I have since found the instrument of service in teaching this rather troublesome subject, and I will, therefore, venture to give an account of some of its performances.

The instrument is exceedingly simple, and consists merely of a form of stably spinning top, not too heavy, having a socket at the bottom of the stem for the axial insertion of the pencil on which the top is to spin. Particular care must be taken, however, to have the top well balanced and the pencil centered, and I have, therefore, sketched in the annexed figure the form with which I obtained my best results. Here a is a thin disc or web of tin plate carrying a circular ring (b) of $\frac{1}{8}$-inch copper wire; c is a thin conical brace to sustain the brass tube (d), which holds the pencil (e) normally to the web. The whole

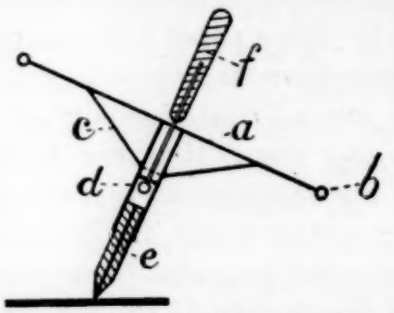


Fig. 1.—Sectional elevation of the top in position for curve tracing (reduced to one-fourth).

is revolvable around the handle (f), the round stem of which passes nicely through central perforations in the web and a diaphragm fixed within the brass tube. The string for spinning is wound around d. The figure is drawn to scale the diameter of the web, being about 6 inches. The weight should not exceed about 5 ounces. It is not desirable to hasten the precessional motion as the curve tracing is best shown with a leisurely swinging top. Furthermore, a tablet at least a foot square, preferably of plate glass, framed and provided with leveling screws, is needed for the accurate delineation of the curves. On this is placed a smooth sheet of white paper. The top, after being spun on the handle, is placed down with its *axis oblique* to the tablet, so that precessional motion may be initiated at the outset.

If the tablet is quite level the curves obtained are spiral with but very slight, if any, lateralness. Two cases are to be distinguished: If the pencil is hard and blunt (preferably cut square off at the lead with a sharp circular edge) precession is markedly accelerated; the top begins with a wide sweep and gradually rising from the oblique to the vertical position, describes a series of spires which converge rapidly from a wide circumference towards a center. If the point is hard and sharp, the top does not rise so

fast, and the tendency is to retain small contracted figures. In both cases, however, the occurrence of spirals is chiefly the result decreasing angular velocity due to friction of the pencil on the tablet, as will be presently shown.

The most interesting results and by far the most beautiful curves are obtained when the tablet is not quite horizontal. In proportion as larger angles of dip are chosen, the spirals increase in lateralness until in an extreme case they merge more and more fully into contracting prolate cycloids. The figures are in the main cornucopia-like and the tracery at proper angles of dip is

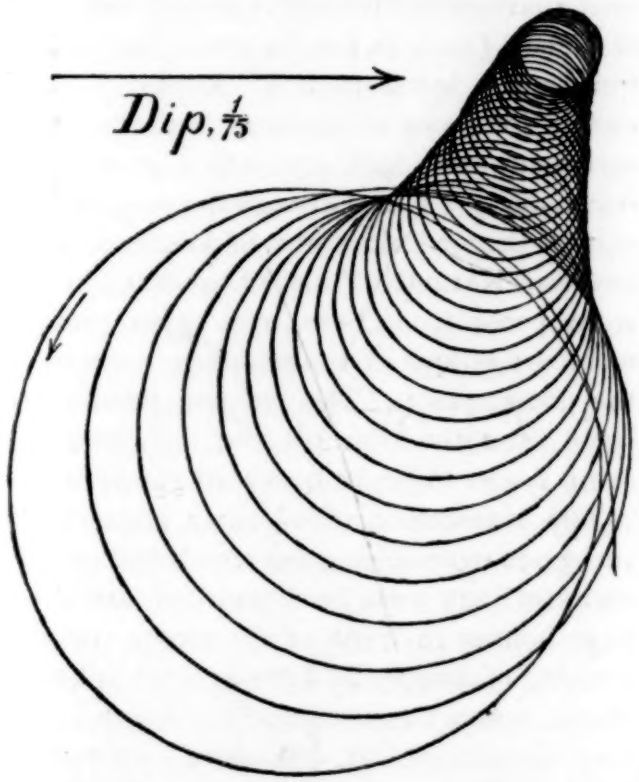


FIG. 2.

exceedingly delicate. Figure 2 is a type of these curves *, to which however an infinite variety may be given, a dip of $\frac{1}{4}$ to 1 inch in two feet being favorable.

One would at first thought suppose that a top on an inclined nearly smooth tablet would tend to describe elongated figures by sliding down the plane. Such, however, as is otherwise known, is only in small part the case. The top moves across the dip, tending to remain, if not quite, at least very nearly, on an average level. Moreover there is a necessary relation between the dip, the direction of rotation and the march of the top across the dip. If the tablet slopes downward from left to right parallel to the observer, the top moves away from him if spun counter-clockwise, and towards him if spun clockwise. If the dip be downward from right to left, the opposite relations of rotations and progression will hold. In other words, if the pivot or stylus of the top were to point in the direction of the dip, the rim or web would roll in the direction in which the top actually moves across the dip.

The reason for this curious behavior might perhaps most simply be looked for in the fact that precession* is relatively less accelerated when the end of the pencil moves up hill and relatively more accelerated when the end of the pencil rolls down hill. Hence if the dip be from left to right and the rotation counter-clockwise as seen from above, the pencil sweeps further out from the center, *i. e.*, away from the observer, because the obliquity of the top axis is being relatively increased. In rolling down hill the pencil sweeps nearer towards the center of motion (*i. e.*, also away from the observer), because the obliquity of the top axis is being relatively decreased. An inspection of the experiment and of the curves drawn by the top does not bear this out. It appears rather that the angular velocity of the top is continually decreased when the pencil rolls up hill and is continually increased again when the pencil rolls down hill. The tops of the spires therefore correspond to a rela-

* Unfortunately the photographic reproduction of these curves was not satisfactory. The above figure is made from a hand tracing of a coarsely drawn curve and does not convey the finish of the originals.

* Following Lord Kelvin's well known explanation.

tively *later*, and the bottoms of the spires to an *earlier* stage than the corresponding mean time of spinning on a plane tablet.

Now if the pencil is hard, so that its circular edge remains nearly constant in radius, the envelope of the cycloido-spirals will consist of two straight lines converging at the point where the top would cease to rotate if the other conditions of motion remained similar. In other words, supposing the period of precession to be nearly constant, the angular velocity of the top would vanish at the point of intersection in question. The cause of the gradual cessation of motion here, as in case of the horizontal tablet, is friction; but in case of the oblique tablet, if the period of percession remains nearly constant, the crests of the spires correspond to smaller angular velocities, and will therefore have smaller radii of curvature than the troughs of the spires where angular velocity passes through a maximum. In other words, the loops will be less obtuse at the top and more obtuse at the bottom of the dip. Part of the energy of rotation is periodically potentialized. To draw such curves the top must necessarily move across the dip.

If the end of the pencil is convex, so that the rolling on the pivot is relatively decreased as the top rises, the envelope of the spires will no longer be straight, but consist of two converging curved lines as shown in the figure.

In the preceding instances the direction of the progressive motion of the top, *i. e.*, the trend of the 'cornucopias,' is nearly a straight line at right angles to the dip. Suppose, however, that for the plane tablet a flat conical one be substituted, which may be either raised or depressed in the center. The dip is now everywhere radial. In this case the progressive motion of the top becomes orbital around the axis of the cone, if the dip be suitably chosen. We have then a very simple arrangement for simulating (except, of course, as to cause, and quantity) the orbital and precessional motion of the earth. Indeed, beautiful fluted curves corresponding to nutational movement may also easily be obtained by slightly destroying the balance of the top, though this interferes somewhat with the smoothness of motion.

C. Barus.

Brown University,
Providence.

MEETING OF THE MAZAMAS AT CRATER LAKE, OREGON.

The annual field meeting of the 'Mazamas,' a club of mountain climbers with headquarters at Portland, Oregon, was held at Crater Lake, in the Cascade Mountains, during the latter part of August. This meeting was one of the most important and successful ever held and was a memorable one in many ways. Through the cooperation of local Crater Lake clubs, of Ashland, Medford and Klamath Falls, about 500 persons were present. There were also present members of four of the scientific bureaus of the government. The various parties arrived from the 14th till the 19th, and the camp began to break up about the 25th.

The Mazamas pitched their tents on an eminence overlooking the wonderful crater, and meetings were held evenings around a huge bonfire in front of the tents. On the evening of August 21st the ancient volcano, whose summit is occupied by Crater Lake, was christened Mt. Mazama. An appropriate address was read by the President, Mr. C. H. Sholes, of Portland. This was followed by a dedicatory poem by the Vice-President, Miss Fay Fuller, of Tacoma, Washington. Then the energetic Secretary, Rev. Earl M. Wilbur, of Portland, acting as 'toastmaster,' introduced the following toasts: To Mt. Mazama, responded to by Mr. J. S. Diller, of the U. S. Geological Survey; to the Poetry of Crater Lake, by Capt. Oliver Applegate, of Klamath

Falls; to the Forests of Crater Lake, by Dr. C. Hart Merriam, Chief of the U. S. Biological Survey; to 'That Tired Feeling,' by Prof. B. W. Evermann, of the U. S. Fish Commission; to the History of the Cascade Mountain National Forest Reservation, by Mr. W. G. Steel, of Portland, late President of the Mazamas. At the conclusion of the exercises a signal gun was fired and the crater of Wizard Island, a cinder cone rising 840 feet from the water of the lake, was illuminated by burning 20 pounds of 'red fire.'

On other evenings informal 'camp fire talks' were given by the government scientists present. Mr. J. S. Diller, of the Geological Survey, gave an account of the geological history of Crater Lake. Mr. F. V. Coville, Chief Botanist of the Department of Agriculture, spoke of the flora of the region and mentioned many facts of historic interest connected with early botanical explorations in the Northwest. Dr. C. Hart Merriam spoke on the fauna of the region and the geographic distribution of life in Oregon with special reference to the Cascade Range. Prof. B. W. Evermann, of the Fish Commission, spoke of the animal life of Crater Lake and its physical features with reference to the introduction of fish.

The government is doing a great deal of scientific work in Oregon this year. Mr. Diller is mapping the distribution of volcanic rocks in the Cascade Range and Rogue River Valley; Mr. F. V. Coville and his assistant, Mr. John Lieberg, have conducted extensive botanical explorations across the State; Dr. C. Hart Merriam, assisted by Messrs. Vernon Bailey, E. A. Preble, C. P. Streator and C. Allen, has carried the work of the biological survey over the greater part of Oregon; and Prof. B. W. Evermann, assisted by Prof. Cox, is engaged in studying the fish faunas of numerous waters in the Northwest. The officers in charge of these several parties were glad to avail themselves of the exceptionally favorable opportunity to study the natural history of the Crater Lake region afforded by the Mazama excursion. Two new boats were built and placed on the lake, and numerous courtesies were extended to the government men by the Mazamas.

Crater Lake is easily the jewel of the Northwest. It is hoped that means of reaching it will be perfected in the near future, so that it may be visited by the thousands of tourists and others who now content themselves with the Grand Cañon of the Colorado, the Yellowstone Park and the Yosemite. It can now be reached by good wagon roads from Ashland, Medford and Klamath Falls, but there are no regular conveyances or stopping places.

Crater Lake is a beautiful sheet of indigo-blue water, about 6 miles in length by $4\frac{1}{2}$ in breadth. It occupies the crater or caldron of an extinct volcano and is completely surrounded by a precipitous wall, varying from 1,000 to something over 2,000 feet in height. A remarkably perfect and symmetrical cinder cone with a crater at its summit forms an island—Wizard Island—which rises 840 feet above the surface of the lake. The lake was sounded by Major C. E. Dutton in 1886 and found to be 2,000 feet in greatest depth. Its surface temperature is 59° or 60° Fahr. The altitude of the rim of the crater varies from about 7,000 to 8,200 feet.

Crater Lake Mountain is covered with a magnificent forest of conifers, arranged in well marked belts or zones, from base to summit. Beginning at the bottom (in the Transition Zone) is a relatively open forest of huge yellow pines (*Pinus ponderosa*), some of which measure 22 feet in circumference. Mixed with these are some sugar pines (*Pinus lambertiana*) and cedars (*Libocedrus decurrens*). At an altitude of about 5,000 feet, on the south and southwest slopes, the yellow pines give place to a

dense forest of the lodge pole, or Murray pine (*Pinus murrayana*), more or less mixed with Douglas spruce (*Pseudotsuga taxifolia*), white fir (*Abies concolor*) and white pine (*Pinus monticola*). This belt is invaded by the hemlock (*Tsuga pattoniana*), and red-bark fir (*Abies nobilis*) of the zone above. At about 6,200 feet the trees of the middle or Canadian Zone fail, except on the warmer exposures, and one enters the superb forest of the Hudsonian or upper zone, a forest of splendid firs (*Abies nobilis*), and sombre hemlocks (*Tsuga pattoniana*), sparingly mixed with the sub-alpine fir (*Abies lasiocarpa*) and white-bark pine (*Pinus albicaulis*). The monstrous cones of the red-bark fir, with their bright red seed wings and exserted bracts, are among the wonders of the vegetable kingdom; while the dark hemlocks, with their drooping branches draped in the long hanging beards of a blackish lichen, rank among the giants, some of their trunks measuring 17½ feet around.

The Columbia black-tail deer (*Cariacus columbianus*) is common on the mountains and furnished our camp with fresh meat. Large trout abound in Klamath Lake, at the south foot of the Mountain, and afford excellent fishing. Klamath Lake is also the resort of thousands of ducks and other waterfowl. Hence the sportsman, as well as the tourist, naturalist, and lover of the grand and beautiful in Nature, is sure to find the Crater Lake region a place of unusual interest. For scenic beauty and grandeur Crater Lake, with its deep blue waters walled in by towering cliffs and rugged crags, ranks among the gems of American scenery. C. H. M.

CURRENT NOTES ON PHYSIOGRAPHY.

DRUMLINS IN SWITZERLAND.

Dr. J. Früh, of Zurich, gives an account of '*Die Drumlins Landschaft*' — following by over twenty years Desor's *Paysage moraine* — with especial reference to the Alpine foreland (Jahresber. St. Gall. naturwis. Gesellsch., 1896). After a serviceable review of the distribution and description of drumlins in other countries, especially Ireland and the United States, the author describes in detail a number of localities, from Lake Constance to the Reuss. Not until 1893 were drumlins recognized in the Alpine foreland; Sieger then describing a group of them on the peninsula between the two arms of Lake Constance (Richthofen-Festschrift). It now appears that the Piedmont area overspread by the Rhine glacier in the latest glacial epoch contains a large number of radially arranged drumlins, whose attitude confirms the divergent direction of ice movement indicated by the dispersal of certain peculiar boulders in a district where striæ are almost wanting. The broad spreading of the glacier on the Piedmont area is shown by the deflection of the drumlins on the extreme right and left of Lake Constance, about 80° from the axis of the lake. The finest drumlin landscape of Switzerland is said to be a little south Pfäffikon, northeast of Lake Zurich, in the district of the Limmat glacier. Früh advocates the subglacial origin of drumlins, comparing them to sandbanks in rivers, as have other authors, but recognizing that some difficulties attend this explanation. In certain localities, the drumlins appear to be formed of overriden moraines.

TOPOGRAPHY OF SOUTHERN TUNIS.

Capt. E. de Larminat, of the geographical service of the French army, makes an interesting study of topographic forms in southern Tunis (Ann. de Géogr., v., 1896, 386–406). The initial form of the region appears to have been an extensive anticlinal dome; but this is now broadly unroofed. A ridge with an infacing escarpment, maintained on a resistant stratum, encloses an inner lowland, eroded on

weaker internal strata. On the northeast the enclosing ridge is nearly lost; but on the southwest it constitutes a well defined semi-circular divide. Larminat describes with much detail the various elements of form thus developed. Outliers (témoins) in front of the escarpment are figured in various stages of breaking down under the cross-examination of the weather. Streams that once drained outward, down the dip of the dome, have been 'confiscated' by the headwater growth of the inner lowland streams. A good figure is given of a dry stream bed (oued=wady) on the outer slope of the enclosing ridge, that maintains a considerable breadth up to the present divide, thus plainly witnessing a transfer of great drainage area from consequent to obsequent streams.

The generality of these phenomena is not referred to by the author. The unroofed dome of the Weald, in southeast England, repeats nearly all of them, even to the broad beheaded valleys that notch the encircling ridge; the few unlikenesses of two regions depending more on the surface expression as determined by climate than on differences in structure or in stage of development. The region of the Swabian Alps, dividing the drainage areas of the Rhine and the Danube, exhibits escarpments, benches, outliers and shifting divides in remarkable perfection. One of the greatest examples of the kind is described by Dutton under the name of the 'San Rafael Swell' in his report on the High Plateaus of Utah. Less notable examples can be given in great number.

GUAYRÁ CATARACTS OF THE PARANÁ.

COUNT P. ANTONELLI gives a spirited narrative of his excursion in August, 1895, to the Guayrá cataracts of the Upper Paraná in southern Brazil (Mem. Soc. geogr. ital., vi., 1896, 80–102). His route eastward from Rosario on the Paraguay led for days through the virgin forests, passing occasional settlements where *yerba mate*, or Paraguay tea, was cultivated; then by canoe down the Yagatimi to the Paraná, just above the cataracts. Although visited by a number of travelers, accounts of the place vary greatly. Antonelli states that above the falls the river is expanded to a breadth of ten kilometers, flowing quietly among many islands; then it plunges suddenly down twenty-two channels over broken granite ledges, descending 25 or 30 meters into a gorge not more than 60 meters wide, through which all the waters are discharged in foaming rapids to the lower river. A route map by surveyor Mariotti and several views from photographs by San Martin are included. As is so often the case, personal narrative is prominently brought forward, technical geographical description is lightly touched, and physiographical relations do not seem to have been even dreamed of.

AUSTRALIAN EXPLORATION.

EXPLORATION in western interior Australia continues to reveal a great expanse of 'desert' having a varied topography, as summarized by several recent writers (Trans. Roy. Geog. Soc. Austr., Victorian branch, March, 1896). J. W. Jones outlines the geographical results of the Elder exploring expedition. J. A. Panton reviews 'Australia deserta.' A. J. Wright gives a narrative of his journey to Coolgardie, in the new gold field of western Australia. All tell of an arid region, broken by bare mountains of ancient rocks, attaining a height of three or four thousand feet; great intermediate areas of limestone and sandstone, much denuded, and holding salt lakes or dry lake beds in the depressions. Even when the surface of the basins is dry, salt water can usually be found a few feet below, 'so that the enterprising miner, with his condenser, can now depend upon the salt lake for a permanent water supply.' At the base of the imper-

vious old-rock ridges, the local accumulation of ground water is known as a 'soak.' Much of the sandy surface is occupied by *Triodia irritans*, known as spinifex, or needle grass; a gray-green, hard spiny bush, growing so dense in places as to impede travelling. Elsewhere there are patches and belts of herbage fit for pasture, and of dense scrub forests. Trains of camels with Afghan drivers are often seen on the way to the gold fields.

NOTES.

The voyage of the Norwegian whaling steamer Antarctic in the South Polar seas, 1894–95, already familiar from the narrative of Borchgrevinck, one of the seamen, is described by the captain, L. Kristensen, in the transactions referred to in the preceding paragraph.

The *Geological Magazine* (London) for March contains an account by Preller of the Merjelen lake, enclosed by the Aletsch glacier, in Switzerland, with an excellent photographic plate.

La topographie aux Etats Unis is the title of an appreciative article by Gen. de la Noë, director of the geographical service of the French army (Ann. de Géogr., v., 1896, 143–155). He gives particular attention to Gannett's Manual of Topographic Methods, with especial praise to the advice on 'sketching,' for which, curiously enough, even the French army engineers have no equivalent expression.

W. M. Davis.

Harvard University.

CURRENT NOTES ON ANTHROPOLOGY.

QUESTIONARIES FOR ETHNOGRAPHICAL RESEARCH.

Various anthropological societies and governments have from time to time published series of queries to guide travellers who desire to study the people in the countries they visit. One was issued in 1889 by the French Sociétè d' Anthropologie, prepared by the able hands of a committee consisting of MM. Hamy, Hovelacque, Vinson and Letourneau. It is needless to add that it is thorough and well digested. Moreover, it is brief, covering only sixteen pages, and yet the committee claim with general justice that no really important points are omitted.

The latest publication of the kind is the 'Instrucktion für ethnographische Beobachtungen und Sammlungen in Deutsch Ost-Afrika.' It is published in the 'Mittheilungen aus den Deutschen Schutzgebieten' (Band IX., 1896, Heft 2), and was prepared by Dr. Von Luschan. The instructions are arranged in a series of questions, 88 in number, and are accompanied by a separate sheet or sheets, to be filled out with somatologic observations. The separata, which are intended for distribution, are interleaved, and contain a number of blank pages at the end for notes and are firmly sewed in linen covers. These minor precautions aid materially in the practical utility of such a publication.

THE TEACHING OF ETHNOLOGY.

In the 'Bastian Festschrift,' Dr. Ernst Grosse has a timely article on the teaching of ethnology in high schools and universities. It is to be regretted that he contrasts ethnology with anthropology, instead of making it a branch of that general science, which it properly is. However, he appreciates what ethnology is in itself, defining it as 'The science of the culture of peoples.' He also assigns it its just position, speaking of it as a 'science destined to open a new era in the whole history of civilization.'

Entertaining these views, he cannot understand why it is so neglected in institutions of education, but inclines to attribute this to its somewhat revolutionary character, and to the limited opportunities it at present offers for pecuniarily profitable

employment. He suggests that in the higher schools one hour a week be given to ethnographic lectures, and that in university courses a double line of instruction be followed, one adapted to all students, setting forth the general principles and aims of the science, another suited to those who would take it as a major or make it a specialty. This plan would, he believes, soon result in that general appreciation of its value which the true ethnologist now claims for it. D. G. BRINTON.

UNIVERSITY OF PENNSYLVANIA.

SCIENTIFIC NOTES AND NEWS.

THE SCIENTIFIC EXPERT.

UNDER the title 'The Imperiled Dignity of Science and the Law,' Prof. John Trowbridge contributes to the October number of *The Atlantic Monthly* an account of the difficulties of the expert witness before legislative committees and courts of justice. Scientific questions are usually too complex to be answered by 'yes' or 'no,' and the man of science is apt to become a partisan in the hands of the counsel who employs him, and then in turn to be discredited by the opposing counsel. There is often room for difference of opinion in regard to scientific questions that must be settled by legislatures and courts, but it is unfortunate for science and justice when experts can be found who will testify for money on the side for which they are paid As Prof. Trowbridge writes:

"The Judge, after hearing the arguments of the learned counsel, is left alone with the voluminous affidavits in which the scientific statements have been pared thin by the lawyers to enable one with no scientific training to see through them. One expert is balanced against another, and the Court is plunged into a state of great perplexity. What wonder that, in a recent case, a Judge remarked that one side having brought forward four experts and the other side five, and the learned professors on one side having testified in direct oppositlon to those on the opposing side, he would give a verdict to the side which brought the greater number of experts; and he therefore ordered an injunction to be issued in favor of the latter."

If the man of science is to be paid at all for expert opinion, it seems evident that he should be employed as a judge and not as an advocate. Prof. Trowbridge concludes:

"The most practical remedy, it seems to me, for the existing evils of expert testimony, would consist in making it customary for a Judge to call to his assistance any professor of science of high attainment who is not engaged by either of the parties in dispute. If the Judge appealed to the State to provide him with scientific advice, and if men eminent in science were selected by the State to aid the Judge in his endeavor to arrive at the truth on scientific points, both the bench and the professional chairs would gain in dignity, and the pursuit of truth would again be considered one of the chief characteristics of a scientific life."

THE U. S. S. 'BROOKLYN.'

THE performance of the U. S. S. 'Brooklyn,' on her recent trial trip, August 27th, admirably illustrates the high state of efficiency attained by our new navy, and, perhaps, even more satisfactorily, that reached by our naval constructors and engineers. The trial was made in deep water, outside Boston harbor, on a course eighty-three miles long, and well out at sea. It is only in water fifteen or twenty fathoms deep that the full sea speed of these heavy and fast vessels can be brought out.

The 'Brooklyn' is a ship of about 9,200 tons displacement—8,250 tons without armament or stores, as on the trial—and was designed, as to hull, by the Bureau of Construction of the Navy Department at Washington, and, as to machinery, by the Bureau of Steam Engineering, of which Commodore Melville, the famous Arctic explorer and no less distinguished naval engineer, is chief. On the trial so perfectly were the engines and boilers proportioned to each other that all the steam that could be made by the latter was worked off by the former, and enough was made at a pressure of 160 pounds per square-inch to drive the engine up to 135 revolutions per minute and to give the ship the unexampled mean speed of 21.92 knots —equivalent to over 25 miles an hour. This is claimed to be the highest speed ever attained by any iron-clad, of any type. It is only exceeded by some unarmored ships of our own navy, as the 'Columbia' and the 'Minneapolis,' and by no other war vessels of any navy in the world.

liver the Bradshaw Lecture at the Royal College of Physicians on November 5th. The title of the lecture will be 'Subjective Sensations of Sound.' The Lumleian lecturer for next year is to be Dr. Bastian, and Dr. Luff will be the Gulstonian lecturer. Prof. Sidney Martin is to deliver the Croonian Lecture in 1898.

THE lecturers before the Peabody Institute, of Baltimore, will include the following: Professors Young, of Princeton; Hale, of Kenwood Observatory, in the University of Chicago; Keeler, of the Allegheny Observatory; Michaelson, of the University of Chicago; Trowbridge, of Harvard University, and Rowland and Ames, of the Johns Hopkins University.

THE Sanitary Institute of Great Britain held its Congress at Newcastle on Tyne, during the week beginning September 2d. The Congress was opened by the Duke of Cambridge, President of the Institute, and an inaugural address was made by Earl Percy, President of the Congress. Addresses were made before the Section of Sanitary Science and Preventive Medicine by Professor Corfield; before the Section of Chemistry, Meteorology and Geology by Mr. W. H. Dives; before the Section of Engineering and Architecture by Sir Andrew Noble, and a large number of papers were presented.

THE eighteenth general conference of the American Library Association, held recently at Cleveland, was attended by 600 members. An address was made by the President, Mr. G. Dana, of the Denver Public Library, and a large number of papers were read during the four days the Association was in session.

PROF. MICHAEL FOSTER will give at St. Bartholomew's Hospital on October 5th the first Huxley lecture, his subject being 'Recent Advances in Science and their Bearing in Medicine and Surgery.'

PROF. LEBER, editor of Graefe's Archiv für Ophthalmologie, was presented with the Graefe medal at the recent German Ophthalmological Congress in Heidelberg.

DR. FORSYTH MAJOR, who for over two years has been engaged in an examination of the fossil and recent flora and fauna of Madagascar, has recently returned to London. The expedition was supported by the Royal Society and the British Museum, and the collections have been deposited in the British Museum. The French government are preparing a still more elaborate expedition to Madagascar under the direction of M. Milne Edwards and M. Grandidier. It is said that 600,000 fr. will be spent on this expedition.

IT is stated that of the six steamers with which Captain Wiggins sailed on the 18th of August from Glasgow, four—namely the Glenmore, Scotia, Dauphin, and Father John of Kronstadt—will remain for service on the rivers and lakes of Siberia. Although his flotilla was late in sailing, it is hoped that he will reach Yenisseisk, or at least Krasnoyarsk, before the season of extreme cold commences.

IT is stated in the daily papers that a test of Octave Chanute's Albatross flying machine, invented and constructed by William Paul, was made at Millers, Indiana, on September 18th, and that though the flight was less than a hundred feet the machine acted in a satisfactory manner.

WE learn from the *British Medical Journal* that the arrangements preliminary to the founding of a Pasteur Institute for India were discussed at a recent meeting in Simla, when Surgeon-Major-General Gore, Principal Medical Officer of Her Majesty's Forces, the Quartermaster-General, the Surgeon-General with the Government of India and Professor Haffkine were present. It is proposed that the Institute should be erected in Kasauli or Darjeeling, and be a general institute, and not one for antirabic work only.

THE two following items are taken from the last issue of *Nature*: "A block of granite bearing the following inscription has, says the *Academy*, been recently placed on the southern shore of the Lake of Sils, in the Engadine: 'In memory of the illustrious English writer and naturalist, Thomas Henry Huxley, who spent many summers at the Kursaal Hotel, Majola.'"

"It is announced that the Royal Society of Canada has resolved to commemorate the five-hundredth anniversary of the first landing of Cabot in North America by holding a meeting at Halifax from June 30th to 26th of next year, and to erect, at a cost of not less than £200, a monument at Sydney, in Cape Breton."

The 'Brooklyn' is 400 feet long, 64¾ feet beam, with a load draught of 24 feet. Her load displacement is computed at 9,153 tons and her engines are rated at 16,000 I. H. P. The contract speed was 20 knots at a displacement of 8,250 tons; but, as in the majority of later constructions, especially by the Cramps, the builders of the 'Brooklyn,' this speed is greatly exceeded on trial, and will undoubtedly even be somewhat exceeded when in sea-going trim. The contractors will make a bonus of $350,000 to $400,000 on the excess of trial speed over the minimum of the contract. This ship is considered unrivalled in conjoined power and speed.

The proposed armament consists in its principal battery, of eight 8-inch B. L. rifles with twelve 5-inch and some smaller ordnance. The armor is light—8-inch. This ship is a thousand tons heavier than the 'New York' and designed for one knot less speed; but she will probably fully equal that ship in this respect. The battery of the 'Brooklyn' is heavier, by two 8-inch and also by carrying 5-inch guns in place of 4-inch.

This is one of the most marvellous of all the examples of modern naval construction yet produced, all things considered, and its concentration of speed with offensive and defensive power is probably without equal. Perhaps we may also conclude that the performance of the 'Brooklyn' affords the best possible evidence of the wisdom of the policy of the creators of modern navies, and particularly of that of the United States, in securing that union of mathematical and scientific professional training with practical experience in the management of these intricate machines at sea which has placed our own engineer and construction corps on so high a plane and has given them the needed theoretical and practical ability to design such marvels of naval architecture as are the floating machines of which we now see our navy composed.

R. H. Thurston.

CHEMISTRY.

It is well known that all atomic weight determinations of tellurium have given results higher than would justify the place it holds in the periodic system, and have led to the supposition that some impurity of higher atomic weight may be present. Brauner's determinations give the figures 127.64; Staudenmaier using different methods has recently confirmed this, his number being 127.6. Acting upon the idea that both of these results were obtained on tellurium from the same or similar sources, Chikashigé has made determinations of a Japanese tellurium which occurs in a massive sulfur, uncontaminated with any of the heavy metals. The method he used is the same as that used by Brauner. The atomic weight found is 127.61 as a mean of three closely concordant experiments, and confirms the previous results. The anomaly of tellurium, as well as that of cobalt in the periodic system, thus remains as unexplained as before.

In a recent Journal of the Chemical Society Herbert McLeod published further investigations on the liberation of chlorin in the making of oxygen from potassium chlorate and manganese dioxid. In opposition to the work of Dr. Brunck, he shows clearly that the active gas liberated is chlorin and that no ozone is evolved. The reaction taking place is probably

$$2MnO_2+2KClO_3=2KMnO_4+Cl_2+O$$
$$2KMnO_4=K_2MnO_4+MnO_2+O_2$$
$$K_2MnO_4+Cl_2=2KCl+MnO_2+O_2$$

The manganese dioxid is continuously reproduced, and only a very small quantity of chlorin ultimately escapes absorption by the manganate.

J. L. H.

GENERAL.

Among the public lectures to be given in connection with the sesquicentennial celebration of the founding of the College of New Jersey and the ceremonies inaugurating Princeton University will be four lectures by Prof. J. J. Thomson on 'The Discharge of Electricity in Gases,' on October 13th, 14th, 15th and 16th; four lectures by Prof. Felix Klein on 'The Mathematical Theory of the Top,' October 12th, 13th and 15th, and one lecture by Prof. A. A. W. Hubrecht on 'The Descent of the Primates,' on October 19th. Men of science in departments of study represented by the lectures are invited to attend, but should make application for tickets before October 5th to Prof. William Libbey.

Nature states that Dr. W. R. Gowers will de-

from America. Under date of August 14th, for instance, its New York correspondent sent this dispatch:

"Still the heat continues, and the odor of the charnel house reigns over the city. From hundreds of decomposing human bodies, and from the rotting carcasses of horses there exhales a stench that is positively sickening. Added to this horror is an epidemic of rabies. Mad dogs are running about the streets, and already more than a score of children have been bitten. The mortality due to the heat yesterday totals up 85 persons."

UNIVERSITY AND EDUCATIONAL NEWS.

MRS. EDWARD ROBY, Mr. E. A. Shedd and Mr. C. B. Shedd have offered the University of Chicago a large tract of land around Wolf Lake and the channel connecting it with Lake Michigan, for the purpose of a lake biological station, and it is also understood that they will erect the buildings for the purpose if the offer is accepted. The gift is valued at $500,000.

THE Lewis Institute, the new Chicago school of technology, the foundation stone of which was laid two years ago, has now been dedicated. The late Allan G. Lewis left, in 1877, $500,000 for the purpose, which has now accumulated so as to make the value of the endowment $1,600,000.

THE Ohio State University is now erecting three new buildings, viz: Townshend Hall, for the accommodation of agriculture and agricultural chemistry, to cost $75,000; a Gymnasium and Armory, to cost $65,000; and one for physiology, zoology and entomology, to cost $35,000.

AT Amherst College Mr. F. B. Loomis has been appointed assistant in biology and Mr. E. S. Newton assistant in chemistry. At Lafayette College Mr. W. O. Pennell has been appointed instructor in mathematics and drawing; P. C. Nugent, instructor in civil engineering, and R. E. Dennis, instructor in chemistry. At Wellesley College, Miss A. M. Claypole has been appointed instructor in zoology, and Miss J. Evans instructor in botany; Miss M. E. Maltby will be acting professor of physics during the absence abroad of Miss S. F. Whitinghead, of the department.

DR. TSCHERMAK, of the Military Medical Academy of St. Petersburg, has been appointed full professor of comparative anatomy and embryology in the University of Dorpat. Dr. Lynen, of Charlottenberg, has been appointed professor of mechanical engineering in the Polytechnic Institute at Aachen.

DISCUSSION AND CORRESPONDENCE.

MR. LOWELL'S BOOK ON 'MARS.'

THE strong title, "The Lick Review of 'Mars'" which Mr. Douglass prefixes to his paper is a misnomer. The book was read, the review was written, the MS. was forwarded to the editor and put in type, wholly in the absence of those of my colleagues who were specially interested in Mars. The responsibility for every statement lies with me and is cheerfully accepted. Nor are any changes now required.

It is a matter of extreme regret to me that Mr. Douglass' comments on my review are so largely personal. I had hoped that one or more of the scientific questions involved might be discussed. My review covered a very limited number of the points which I had desired to bring up; at many points in Mr. Lowell's argument the connection of cause and effect is not clear; and the subject is important. I sincerely hope that Mr. Douglass will write anoanother paper and devote it to the scientific side of Mars.

I again wish to acknowledge my indebtedness for the quotations from one of Schiaparelli's papers translated at Flagstaff by Prof. W. H. Pickering, from which I quoted and to which I gave credit. But many of us had previously read Schiaparelli's *earlier* papers in *Himmel und Erde*, in Flammarion's *Mars* and in the transactions of the *Reale Accademia dei Lincei*, and had found them full of facts determined and theories faintly suggested to which the modern writer of a book on Mars could conscientiously give credit.

It is true, as Mr. Douglass suggests, that Schiaparelli claimed to have observed seasonal changes on Mars. It is also only too true that Mr. Lowell's book does not mention the eminent Italian's observations of such changes. For my pains in quoting Schiaparelli's own description of the seasonal changes observed by

We record with much regret the death of William Crawford Winlock, assistant in charge of the office of the Smithsonian Institution. He died at Bay Head, N. J., on September 20th, at the age of thirty-seven years. Mr. Winlock was the son of the eminent astronomer, Joseph Winlock, and had himself made valuable contributions to astronomy while occupied with executive work of much importance for the advancement of science.

Mr. Enoch Pratt, who endowed a free library in Baltimore with over $1,000,000, and had given other sums for educational and philanthropic purposes, died at Baltimore on December 17th, at the age of eighty-eight years.

M. Henri Resal died at Annemasse, Haute-Savoie, on August 22d, at the age of sixty-eight years. M. Resal was the author of many works on mining engineering, a member of the Paris Academy of Sciences and editor of the *Journal des mathématiques pures et appliquées.*

The Marine Biological Association, at Plymouth, England, is about to publish, through Macmillan & Co., a book on the natural history of commercially valuable sea fishes, entitled 'The Marketable Marine Fishes of the British Islands.' The work, which is now in press, has been prepared by Mr. J. T. Cunningham, with the assistance of Prof. E. Ray Lankester and the Council of the Association.

Mr. R. Ellsworth Call has in preparation a work on the Mammoth Cave of Kentucky which will be in large quarto with about 30 plates. The edition is limited to 200 copies, and will be sold only by subscription, which should be sent to the author, care of John P. Morton & Co., publishers, Louisville, Ky.

Messrs. D. Appleton & Co. make the following additional announcements: *Dynamic Sociology*, by Lester F. Ward; *Pioneers of Science in America*, edited by Dr. W. J. Youmans; *The Evolution of the Art of Music*, by C. Hubert H. Parry, new volumes in the International Scientific Series; *Our Juvenile Offenders*, by W. Douglas Morrison, a new volume in the Criminology Series; *Genius and Degeneration*, by Dr. William Hirsch.

A severe earthquake occurred in Iceland on August 26th and 27th, causing the destruction of many buildings.

Dr. Max Wolf discovered, at Heidelberg, on the evening of September 7th, four new minor planets; he had discovered one on September 3d, and their number now amounts to about 420.

Mr. Max Osterberg, of Columbia University, will give a lecture on the possibilities and limitations of the Röntgen Rays in Association Hall, New York, on the evening of September 25th. The proceeds will be devoted to securing apparatus with which to illustrate the instruction in the class room of the Y. M. C. A.

According to *Electricity*, in twenty-five years the total number of United States patents rose from 98,460 to 568,619. Of the latter number, electric generators claim 3,117; electric railways, 2,019; electric lighting, 3,622; electric power, 1,183; telegraphy, 3,205, and telephony, 2,459.

The Railway Gazette quotes, from the Bulletin of the Society of Engineers of France, experiments made on the use of pneumatic tires; the results obtained showed that with an empty carriage moving at a walk through the snow the draft was 35.9 lbs with the iron wheel, and but 25.2 lbs. with the pneumatic tire. At a trot, with a load of 660 lbs., the pull was 68.6 lbs. and 39.5 lbs. respectively. In the mud, under the same condition of load and speed, the pulls were 35.2 and 50.7 lbs. for the iron wheel, and 23.1 and 31.2 lbs. for the pneumatic tire. The other tests consisted of pulls of varying speeds over macadam, paved and ordinary roads, and in every instance the pneumatic tire showed a saving in pulling power of from 30 to nearly 50 per cent.

The Japan Mail Steamship Company proposes to run a line of steamships between Japan and Seattle, Washington. The company is said to be very successful and already to own fifty steamships, while twelve new steamships will be constructed for oceanic service.

'The Lounger' writes in *The Critic:* "Display headlines give the London *Daily Mail* quite the air of an American newspaper * * * That the sensational aspect imparted by the glaring headlines does not always belie the text, is clearly shown in its cablegrams

him, I am charged with an 'attempt to seize the credit,' and with taking part in a 'proceeding;' and the quotation is 'irrelevent!'

The Mt. Hamilton observations of canals within the dark regions were made in 1892. Mr. Douglass says that he and Prof. Pickering also observed them, at Arequipa, in 1892. What I objected to was the fact that Mr. Lowell's book speaks of them as if they were discovered at Lowell Observatory, in 1894, by Mr. Douglass and were absolutely new. The 1892 observations, by two other observers, are entirely overlooked by Mr. Lowell. For venturing to suggest that their history did not begin in 1894, I am charged with an 'act of appropriation.' Further, so long as Mr. Lowell considers the network of fine dark marking to be, not water, but *vegetation*, and persists in calling them 'canals,' he cannot object when another observer of a more scientific turn of mind chooses to call them 'streaks,' so long as no one knew, and no one even now knows, their real character.

The first projections on the terminator of Mars were observed at Mt. Hamilton in 1890. The first one was, as Mr. Douglass says, detected by a visitor on one of the public Saturday nights. All the facts there are in the case were published by the Lick Observatory staff on two or more occasions, and Mr. Douglass is indebted wholly to those published accounts for his information. The *morale* of this observatory is such that full credit is always given in such a case. If the other observatory in question had been equally disposed to give credit I should not now have to give the history of the subject. Mars was not regularly observed at Mt. Hamilton in 1890. The great telescope was devoted to other important work. On Saturday nights the telescope was directed upon Mars for the benefit of 100 to 300 visitors, and at such times the astronomer in charge very often did not place his eye to the telescope for several hours. It was on one of those occasions that a very prominent projection presented itself. For suggesting that the history of the prominences did not begin in 1894, I am charged with 'an attempt on the rights of property.'

About vegetation, what did Schiaparelli say? He said the variations observed might be the result of 'extensive agricultural labor and irrigation upon a large scale.' The observed appearances might be explained by 'changes of vegetation over a vast area.' And his comment on those theories is as follows: "For us, who know so little of the physical state of Mars, and nothing of its organic life, the great liberty of possible supposition renders arbitrary all explanations of this sort, and constitutes the gravest obstacle to the acquisition of well-founded notions." Nor is this all, for Prof. W. H. Pickering suggested the same theory many years ago.

About Mr. Douglass' paragraph 8, what are the facts and why does he not publish them? Here are the facts: In 1892 at Alleghany Observatory it was determined that the markings on Mars came to the central meridian 7 degrees (about 28 minutes) later than the predicted time and attention was called to the discrepancy. In 1894 Mr. Lowell at Flagstaff observed the same discrepancy, but estimated its value at 5 degrees (about 20 minutes). Here are two observations of the same discrepancy. One observer of long experience estimates it at 7 degrees; and the other observer at 5 degrees. In the book under review the 5-degree estimate is unfurled to the breeze from Flagstaff, whereas the 1892 results are not even displayed at half-mast, though the author was aware of their existence. And yet when my review called attention to the fact that the discrepancy was observed and commented upon in 1892, Mr. Douglass says that it 'will be seen to be an error.'

My remark "that there should be so many evidences of *apparent* lack of familiarity with the literature of the subject" was certainly the most *charitable* form in which I could speak.

W. W. Campbell.

SCIENTIFIC LITERATURE.

The Primary Factors of Organic Evolution. By E. D. Cope, Ph.D. Chicago, The Open Court Publishing Co. 1896.

In *Primary Factors of Organic Evolution*, Prof. Cope is no longer a setter-forth of new doctrines, but "the present book is an attempt to select from the mass of facts accumulated by biologists, those which, in the author's opinion,

throw a clear light on the problem of organic evolution, and especially that of the animal kingdom." (p. v.) That he has well succeeded in this attempt Neo-Lamarckians will be likely to give cordial assent upon reading these pages. But those who believe that natural selection has played a chief and essential rôle in all evolution will not be so well pleased with Prof. Cope's account of the matter.

The book is a direct plea for the efficiency of those factors of evolution which were prominently set forth by Lamarck and further elaborated by later writers; and it will stand as the most concise and complete exposition of the doctrines of the Neo-Lamarckian school hitherto published; pervaded, however, by the extreme Copean doctrine that consciousness is the prime mover in all organic evolution. This latter doctrine, elaborated and brilliantly expounded by Cope in his 'Origin of the Fittest,' and called Archæsthetism, though barely suggested previously by Erasmus Darwin, constitutes the fundamental thesis of Cope's theory of organic evolution. He describes it in the following words:

"It maintains that consciousness as well as life preceded organism and has been the *primum mobile* in the creation of organic structure. This conclusion also follows from a due consideration of the nature of life. I think it possible to show that the true definition of life is: *Energy directed by sensibility, or by a mechanism which has originated under the direction of sensibility.* If this be true, the two statements that life has preceded organism, and that consciousness has preceded organism are coequal expressions." (P. 513. Quoted from 'Origin of the Fittest,' p. 428.)

That Prof. Cope regards this consciousness as distinct from the physical basis of protoplasm which it is conceived to influence is shown by the following quotation:

"The relation of consciousness to the physical basis is as yet a profound mystery, but that they exercise over each other a definite mutual control is unquestionable." * * * "In other words, the forms of thought, which have no weight, direct the movements of muscles, which have weight." (P. 506.)

In like manner another quotation indicates that his conception of consciousness distinguishes it from a form of energy, for he says: "Whether the intrinsic energies which accomplish evolution be forms of radiant or other energy only, acting inversely as the square of the distance, and without consciousness, or whether they be energies whose direction is affected by the presence of consciousness, the energy is a property of the physical basis of tridimensional matter, and is not outside of it, according to the doctrine we are about to consider." (P. 1.)

While the phenomena of life are thus conceived of as fundamentally influenced by this, may I call it unknown quantity, consciousness, Prof. Cope recognizes the fact that the actual phenomena themselves are the direct expression of some form of energy.

"The phenomena of growth are also evidently exhibitions of energy. The term energy is used to express the motion of matter, and the building of an embryo to maturity is evidently accomplished by the movement of matter in certain definite directions. The energy which accomplishes this feat is, however, none of those which characterize inorganic matter." (P. 475).

This energy peculiar to living organism is called Bathmism.

"All the mechanisms necessary to the mature life of the individual are constructed by the activity of the special form of energy known as growth-energy or Bathmism. It is the modifications of this energy which constitute evolution." (P. 479.)

Having constructed this conception of an energy which may be present in definite quantities in any particular individual, the energy or mode of motion is treated of as a measurable somewhat, which may be passed from one individual to another, as is illustrated by the following passages:

"All this means that a certain limited quantity of energy is at the disposal of each individual organism." (P. 481.) "The most rational conception of this inheritance of structural characters is the transmission of a mode of motion from the soma to the germ-cells. * * * The bathmic theory of heredity bears about the same relation to a theory of transmission of the pangenes of Darwin, or the ids of Weismann, as the undulatory theory of light and other forms of radiant energy does to the molecular theory of Newton." (P. 480.)

As one speaks of the absorption or dissipation of light or heat, so he speaks of the phenomena of organic growth as involving

"the absorption of energy and not its dissipation." (P. 483.)

In elaborating this theory energies are distinguished into two classes. The first class includes those which tend away from the phenomena of life, 'catagenetic,' some of which are exclusively organic, myism and neurism; while others are both organic and inorganic, as gravitation, cohesion, chemism and radiant energy. The other class, 'anagenetic,' includes only those which tend toward the phenomena of life. The particular form of this "energy, which is displayed by the plant in the elaboration of living from non-living matter is called antichemism" (p. 483), the other growth-energies are called 'bathmisms.' Bathmisms are further subdivided according as they are influenced by the interference of energies which are derived from sources external to the germ plasma.

To the 'simple growth force,' which is directly inherited without interference of other forces is given the name 'emphytism,' to distinguish it from the modified forms of growth force called 'grade growth force,' to which the name bathmism is strictly applied. As the author remarks, "pure emphytism can only be observed in the embryos of sexless or parthenogenetic origin, and in the repair of tissues." (P. 485.)

We thus are left with bathmism as the mode of energy, and bathmogenesis as the process by which the phenomena of evolution are accomplished.

As the present writer understands the author, his idea is that it is through the interaction or interference between energies from without the germ, though not necessarily outside the soma, and the particular bathmic energy of the germ itself which determines the specific morphological characters of each organism.

Under Part II., 'The Causes of Variation,' the author discusses the ways by which these interferences are accomplished. These external influences are found to be of two classes, physicochemical (molecular) and mechanical (molar). The class of evolutional phenomena resulting from interference between the molecular energies and bathmism are given the name 'Physiogenesis,' those resulting from interference between molar energy and bathmism are called 'Kinetogenesis.'

In the chapter on physiogenesis are found illustrations quoted from various authors of cases of physiogenesis, as the conversion of Artemia into Branchinecta; the production of colors in Lepidopterous pupæ; the effect of feeding on color in birds; the blindness of cave-animals, etc.

In illustration of the law of kinetogenesis the studies made by Dall on the origin of the plaits in the columella of the Gastropods, and by Jackson on the mechanical origin of characters in the Lamellibranchs, are cited from the Invertebrata.

Kinetogenesis in the Vertebrata is elaborately illustrated by numerous references to the work of other authors and his own researches, on the effects of 'impact' and 'strains,' in modifying osseous tissue, the form of limb articulations and vertebral center, on the increase of size through use, the size and number of digits and the modification of the shape of horns, etc. But perhaps the most interesting and satisfactory application of the law is seen in the explanation of the mechanical origin of dental types, in which the paleontological evidence has proven of the greatest value and has given powerful confirmation to the general neo-Lamarckian theories, which find their strongest supporters among the vertebrate paleontologists of the United States.

The effects of disuse are also exemplified in the cases of atrophy, abortion and modification of limb-bones in mammalia.

This 'use and disuse' of Lamarck, under the modes of physiogenesis and kinetogenesis, are the processes through which variation of form and structure are attained.

Natural selection is recognized as a means and mode of the accentuation and preservation of modifications found to be useful; but the author is particular to note that natural selection does not induce variability, but simply preserves such variations as arise and are beneficial to the being under its conditions of life, quoting from Darwin in support of this view (p. 4). Thus he takes exception to the extreme Neo-Darwinian, or Wallacean doctrine, as it is called by Romanes, in so far as to deny that species and the distinctive characters of every species are due to natural selection.

In Part 1st the common phenomena of evolution are expounded by examples of a vivid

nature under the three headings—variation, phylogeny and parallelism.

The chapter on phylogeny brings together a number of pertinent examples from the facts of vertebrate paleontology, while variation and parallelism are illustrated by both the Invertebrata and the Vertebrata.

Under the subject of heredity over thirty pages are devoted to the defense and proof of the reality of transmission of acquired characters, and for this purpose are cited a goodly array of evidences from both embryology and paleontology.

The particular memory theory of heredity, of which the general principles were stated by Sedgwick as early as 1863, and elaborated by Cope in 1889, formulated by Herring in 1870 and named 'Mnemnogenesis' by Hyatt in 1893, is adopted as best expressing the authors view. The following passage presents a characteristic definition of this factor of evolution.

"It appears to me that we can more readily conceive of the transmission of a resultant form of energy of this kind to the germ-plasma than of material particles or gemmules. Such a theory is sustained by the known cases of the influence of maternal impressions on the growing fœtus. Going into greater detail, we may compare the building of the embryo to the unfolding of a record or memory, which is stored in the central nervous organism of the parent, and impressed in greater or less part on the germ-plasma during its construction, in the order in which it was stored. This record may be supposed to be woven into the texture of every organic cell, and to be destroyed by specialization in modified cells in proportion as they are incapable of reproducing anything but themselves. The basis of memory is reasonably supposed to be a molecular (or atomic) arrangement from which can issue only a definite corresponding mode of motion." (P. 451.) "The somatic cells retain only the record or memory of their special function. On the other hand, the reproductive cells, which most nearly resemble the independent unicellular organisms, retain first the impressions received during their primitive unicellular ancestral condition; and second, those which they have acquired through the organism of which they have been and are only a part." (P. 453.)

To the question what are the primary factors of organic evolution from a causative point of view, the author's answer in brief seems to be as follows: *Bathmism* an intrinsic energy of living matter; *consciousness*, a guiding influence, 'intrinsic in the evolving matter,' but preceding organization; *molecular and molar forces* from without reacting upon bathmism in the processes of Physiogenesis and Kinetogenesis; and the effects of these interactions preserved and perpetuated in heredity through the agency of *memory* in the process called Mnemnogenesis. Viewed as a series of phemonena the author has summarized the particular form of doctrine defended in his book in the following words:

1. Variations appear in definite directions.
2. Variations are caused by the interaction of the organic being and its environment.
3. Acquired variations may be inherited.
4. Variations survive directly as they are adapted to changing environments (natural selection).
5. Movements of the organism are caused or directed by sensation and other conscious states.
6. Habitual movements are derived from conscious experience.
7. The rational mind is developed by experience, through memory and classification (p. 14).

Most, if not all of the particular views of the author found in this book have been more or less fully elaborated in previous papers; but in their connected systematic form, combined with the views of other workers to constitute a consistent doctrine of evolution, we have in 'Primary factors' a valuable text-book for teachers and students.

Whether they will be helped toward an intellectual comprehension of the true factors of evolution by this attempt to express them in terms of those highest of all, most complex and least understood of organic phenomena, consciousness and memory, may be seriously questioned.

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The Manufacture of Explosives. By OSCAR GUTTMANN. 2 Vols., pp. 348 and 444 lg. 8vo. New York, Macmillan & Co. 1895.

As the sub-title of this book indicates, the author has sought to produce a theoretical and practical treatise on the history and the physical and chemical properties, as well as on the methods of manufacture of explosive substances, and he has followed for this purpose the plan adopted in the excellent treatises on Gunpowder

by G. Upmann, and on Explosive Bodies and Fireworks, by E. von Meyer, published in Brunswick in 1874, and which were translated, revised and enlarged by E. Désortiaux in the admirable work published in Paris in 1878. Following Désortiaux's plan, Volume I. of Guttmann's work is devoted partly to a description of the sources, methods of production and properties of the raw materials used in the manufacture of explosives, and partly to the manufacture, properties and the chemical and physical tests of 'Black Powder,' while Volume II. treats of gun-cotton, nitro-glycerin, dynamite, blasting gelatine, nitro-substitution explosives, smokeless powders, caps, detonators and fuses; considerable space being given to the description of apparatus for testing the velocity, pressure and power of explosives, and to the discussion of methods for their storage and transportation and the construction of factories. There is in addition some seventeen pages of a bibliography which is far from being exhaustive.

From his occupation, for many years past, as a builder of works and inventor of apparatus for use in the manufacture of explosives, Mr. Guttmann has had unusually good opportunities for becoming familiar with the art, but owing to his confidential relations with his clients, it is not to be expected that much will be published that has not already been made accessible in periodical literature or patent publications, so that the work is to a large extent historical and suggestive. As a consequence of his occupation there is a lack of perspective in the work, his own inventions being given undue prominence.

Notwithstanding that Mr. Guttmann has been for many years the abstractor in this subject for *Dingler's Polytechnische Journal*, he shows a singular lack of familiarity with American methods and products, which differ materially from those in vogue in Europe, but as a treatise on European practice this work is a sound and trustworthy one. It is probably because of this lack of acquaintance with America that when the author is treating of the history of compressed powders, Professor Doremus, of New York, becomes transformed into General Doremus of Russia.

The chapter on smokeless powders is especially to be commended as probably the most detailed and exhaustive description of the processes of manufacture in use extant, but it is in error as regards indurite.

The style is usually clear but sometimes involved, as when, in discussing the errors of Kopp's Volumenometer and Say's Stereometer, the author says "so that the results obtained with this apparatus only show the atomic weight of the proportions of the various kinds of powder;" there is a lack of uniformity in the use of the chemical nomenclature which is likely to prove confusing; there is an uncertainty at times regarding the constitution of organic substances which is likely to prove misleading; and there are occasional errors, notably where the author after stating that nitro-glycerin freezes at +8° C. (46. 4° F.) says "some experiments made by the author showed that pure nitro-glycerin, if suddenly exposed to a temperature of 25° C. (13° F.), produced by a freezing mixture, was not frozen even after some hours," yet on the whole the work is a very good one, and it is most liberally illustrated with 328 well executed cuts.

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NEW BOOKS.

Humphrey Davy, Poet and Philosopher. T. E. Thorpe. New York, The Macmillan Co. 1896. Pp. vii+236. $1.25.

Elements of Geology. Joseph Le Conte. 4th edition, revised and enlarged. New York, D. Appleton & Co. 1896. Pp. xiv+670. $4.00.

Biological Lectures Delivered at the Marine Biological Laboratory of Wood's Holl, in the Summer Session of 1895. Boston and London, Ginn & Co. 1896. Pp. 188.

The Nursery Book. A complete guide to the multiplication of plants. L. H. Bailey. 3d edition. New York and London, The Macmillan Co. 1896. Pp. xi+365. $1.00.

Report of the Commissioner of Education for the Year 1893–1894. Volume I. Washington, Government Printing Office. 1896. Pp. xlvii+1061.